SCHOOL SCIENCE AND MATHEMATICS

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THE FIFTIETH ANNIVERSARY CONVENTION

PAUL L. TRUMP

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As this is being written, I am glad to report that plans for Central Association's 1950 Fiftieth Anniversary Convention are progressing in fine shape. As you read this, I believe I can assure you that we will have followed through on the blueprints of the program and convention arrangements which you will find inspirational, challenging, and constructive.

The National Council of Geography Teachers has accepted the invitation of our Central Association to join with us in holding their convention. We are glad to welcome them. We are fortunate to be able to share aspects of their program and to share parts of our program with them.

This added emphasis at our meetings this year again highlights a basic characteristic of our organization. The advantage to teachers in separate subject matter areas of meeting with those in their own fields of specialization is enhanced by the advantage of like association and deliberation with teachers in related subject areas.

You must keep your calendar free on the dates November 24 and 25 and plan to join in the good fellowship and professional stimulation of our meetings at the Edgewater Beach Hotel in Chicago. Personal friendships will be created and renewed. We will profit from mutual efforts to sharpen perspective in viewing our opportunities and responsibilities as teachers of science and mathematics in a developing democracy of enlightened people.

A UNIFIED AND CONTINUOUS PROGRAM IN MATHEMATICS*

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A "unified program" exists only when it exists in the mind of the student and the values associated with such a program are realized only when the inherent unity is recognized by the student. To achieve this desirable purpose it is not only essential that teachers and administrators understand the nature of the relationships between the different fields of experience but it is also necessary that the activities of the classroom be so planned that the student becomes increasingly conscious of a continuing and persistent emphasis on common general objectives. Teachers of mathematics share this responsibility with other faculty members, and the program in this area should contribute to the desirable objectives of general education and should also meet the needs of those students whose educational plans call for competency in professional and technical fields. How can this be done? Among the factors to be considered in studying this question are the following:

1. *The attitude of the teacher toward mathematics*

One point of view which represents the position of many teachers is reflected in the following quotation from Professor T. J. McCormack who in 1910 stated that:

> Our science, at least, is not a new and growing science but received its full development centuries ago . . . . No mathematical author is now perplexed with doubts as to new subject matter which he should introduce into his textbook as is a physicist.

On the other hand, Professor J. W. Young, after considering certain characteristics of mathematics, states that:

> Such considerations should tend to eradicate the all too common feeling that the fundamental conceptions of mathematics are fixed and unalterable for all time. Quite the contrary is the case. Mathematics is growing at the bottom as well as at the top.

To accept the position of Professor McCormack is to regard mathematics as a finished and perfected system to be *given* to the student. Memorization is encouraged and through the ministrations of some mathematical Moses to whom the mysteries of mathematics were revealed in a Mt. Sinai experience an uncritical group of students is led into the promised land of absolute truth where all creative thinking ceases.

* Address delivered at the Mathematics Conference at Illinois State Normal University on April 23, 1949.

On the other hand, to teach mathematics as a unified field which is "growing at the bottom as well as at the top" and one in which the "fundamental concepts" are not "fixed and unalterable" is to stimulate the thinking of the student and to extend his growing understanding of these concepts as they relate to the broad fields of human experience.

2. *The selection of the fundamental and unifying concepts*

Mathematics is not a set of isolated and unrelated topics. It is a system of ideas unified by a number of fundamental concepts which grow in meaning and significance for the student as his study of mathematics continues. To develop insight and understanding concerning the nature of these concepts is the major responsibility of the mathematics teachers on all levels while it is also a part of the general responsibility of all teachers regardless of the area with which they may be associated. Among the most important of these concepts are:

2.1 *Number*

Beginning with the idea of a whole number this concept has grown to include fractions, decimals, signed numbers, and on through complex, transcendental and transfinite numbers. Faced with problems born out of his experience man created the language by which it was possible to deal with those problems and according to Professor H. E. Slaught "the perfected number system is, in many respects, the greatest achievement of the human race." Associated with this concept are such related understandings as:

The base of a number system
The importance of zero
The meaning and significance of place value
Operations made possible by extending the concept
The importance of number in our modern society.

The study of this growing and expanding concept is a study of the mind of man at work. It yields many values which belong in the general education of all our students and it includes ideas needed only by those who for one reason or another wish to specialize in the field. It embraces a large segment of mathematics and, in fact, mathematics has well been defined as "the science of number."

2.2 *Measurement*

To develop young people who understand and know how to

use the "techniques of accurate measurement" is indeed a highly desirable objective and is one which should receive continuing and persistent emphasis in any program of general education. Measurement is the art by which the mighty forces of nature are brought under control, and as has often been said "to measure is to know." The story of measurement is the story of man searching for a standard with invariant properties and associated with this important concept are such ideas as:

The importance of standard units
The arbitrary character of the units
The distinction between exact and approximate numbers
The distinction between accuracy and precision
The importance of relative error

The importance of measurement is seen in all the activities of life. It permeates the fabric of modern society. It gives form and direction to our culture and through our control over the techniques of measurement we are building the world of tomorrow. In any program dedicated to the general education of our people we have an obligation to provide experiences through which all students develop insights and understandings related to this important concept. While this is the common responsibility of all teachers on all levels the major burden rests with the teachers of mathematics for it should not be forgotten that mathematics has also been defined as "the science of measurement."

2.3 *Relationship*

The importance of this significant concept with its associated ideas of "change" and "interdependence" is reflected in such phrases as "appreciation of quantitative relationships," "cause and effect relationships" and "the interdependence of the nations and peoples of the world." In our professed allegiance to the "methods of science," accompanied by "our continuing emphasis on the value of the scientific method" we are implicitly recognizing the importance of relationships since in the words of Henri Poincaré, "it is not things themselves that science can reach but only the relations of things," and this judgment is supported by Professor E. R. Hedrick who says that "We seek in modern science to express as best we may the observed facts of nature in the form of the relationships between quantities." To think at all is to think in terms

of relationships and one of the major objectives in any effective program of general education is to improve the quality of this thinking. From his first introduction to mathematics in the early grades to the completion of a graduate program in this area the student is dealing with well defined concepts and examining the nature of the relationship between them. Mathematics, in fact, has been defined as "the science of necessary relations" and teachers of mathematics have a responsibility to provide experiences through which will be developed such understandings as:

The interdependence between all elements of society and the nature of the relationship between these elements.
Methods by which the nature of relationship between classes of variables may be studied.
The table of values as an expression of a relationship.
The graph as a picture of a relationship.
The formula as a generalization of a relationship.
The verbal statement as a means of expressing a relationship.
The nature of interpolation and extrapolation.

From the influential pen of John Dewey comes the statement that "all authorities agree that the discernment of relationships is the genuinely intellectual matter; hence the educative matter. The failure arises in supposing that the relationships can become perceptible without experience." It should be pointed out, however, that the "experience" of our students which leads to the detection and symbolic expression of relationships among the well defined concepts of mathematics must not be limited to that field alone. If the abilities and generalized understandings thus developed are to be useful in dealing with the problems of life it is essential to provide "experience" which calls for the applications of these abilities and understandings to the problems of life, and any teacher of mathematics who fails to do this is not effectively using mathematics as a vehicle for the general education of his students.

2.4 *Proof*

One of the important characteristics of a democracy is the freedom of individual judgment. Associated with this freedom is the accompanying responsibility for making judgments which are not the result of whim or prejudice but which are

consistent with all available data related to the problem under consideration. In any program of general education, it is thus important to examine the methods by which conclusions are established and to assist the student in developing the ability to test the validity of his conclusions. While this is the responsibility of all teachers, the teacher of mathematics has available a type of content which can be effectively used to focus attention on the inductive and deductive processes and to develop such understandings as:

The interplay of deduction and induction in reaching generalizations.
The necessity and significance of undefined terms.
The importance of clearly defined terms.
The significance of assumptions of unproved propositions.
The importance of detecting implicit assumptions.
The distinction between fact and assumption.
The nature of the "if-then" principle.
The ways by which a hypothesis can be proved or disproved and the fact that nothing is proved that is not implied by the assumptions.

On all levels of experience teachers have an obligation to develop the idea that a problem is not completely solved until the conclusion has been validated. Through the checking of results in the early grades to the organizing of authorities in the deductive proofs of demonstrative geometry there should be a continuing and persistent emphasis on understandings related to this important concept. Nor can the experience of the student be limited to a narrow concept of mathematics if he is to be expected to use these understandings in dealing with the affairs of daily life. Through appropriate experiences the student must be led to recognize that methods of proof, clarified through the sharply defined concepts of mathematics, can be effectively used in any field which calls for clear thinking and logical judgment. Mathematics is indeed "the science of necessary conclusions" which is a definition which has long been recognized as reflecting the spirit and scope of this great science.

2.5 *Operation*

Throughout our teaching of mathematics there has been heavy and continued emphasis on this important concept. Many of our students have become competent operators with little understanding of what operation to use and when to

operate. From every mathematics classroom in the country there comes the echo of the common question, "Do I multiply or do I divide?" The operations of mathematics are indeed important but to emphasize them alone is to neglect those very aspects of mathematics which give meaning and significance to these operations. There is also considerable evidence to support the statement that our students do not actually understand these elementary mathematical operations. Do they recognize counting as the really fundamental operation? Are they taught the relationship between addition and subtraction? Do they know that multiplication and division are inverse operations? Are they conscious of the fact that if they square a number and then proceed to find the square root of the result they should get the original number? Understandings of this sort are essential in the intelligent solution of any equation which calls for nothing more than the undoing of the operations which have been performed on the unknown. There is likewise an order in which these operations must be performed just as there is an order of operations in wrapping and unwrapping a package or in starting and stopping a car. With the exception of counting, for every operation of mathematics there is an inverse operation and mathematics may well be defined as "the science of neutralizing operations."

2.6 *Symbolism*

It is the symbolism of mathematics which is at the same time the source of its power as well as its difficulty. Students are permitted and in fact frequently encouraged to manipulate the symbols of mathematics with little or no understanding of the ideas symbolized. A child who writes $3+4=7$ and who has had no real tangible experience with the ideas represented by these symbols might as well be writing Choctaw. The meaning would be just about as clear in one case as in the other. It is, however, the symbolism of mathematics which provides a powerful and effective means of dealing with ideas and it is through well selected symbols that the intellectual power of man is increased. Contrast, for example, the difficulty of finding the product of eighty-four and thirty-seven when these numbers are expressed in the symbolism of the Romans with that of computing the product through the use of the Hindu-Arabic symbols. All languages have in common the use of symbols. There is the language of art and the language of science. There is the language of poetry and the language of mathematics. The artist uses color and canvas, the sculptor

uses stone, the poet uses words, and they all use symbols as a medium for the communication of ideas. Mathematics is the language of exact and accurate thinking and in the words of H. G. Wells "the new mathematics is a sort of supplement to language, affording a means of thought about form and quantity and a means of expression more exact, compact, and precise than ordinary language.

Throughout this discussion mathematics has been defined in a number of different ways but no single one of these really defines mathematics any more than an elephant can be described in terms of its trunk alone. A program in mathematics designed to contribute to the general education of all our students will provide continuing and persistent emphasis on each of these six concepts. They are the threads by which the program is unified and through which it is related to other areas of learning.

INTERESTING NEW APPARATUS

For Physics

An unusual e/m apparatus supplies the important element of interest to a high degree. Even in experiments of university grade, interest is the prime factor contributing to satisfactory performances.

The apparatus is designed around a vacuum tube internally illuminated in dim light by a stream of electrons emanating from a hot tungsten filament through a slit in the side of an enclosing metal cylinder. Mercury vapor inside the tube renders this stream of electrons visible. (Ordinarily the stream forms a white spot on the wall of the tube.) As the current is sent through the pair of coils surrounding the tube the visible stream of electrons curls into a circle like a living thing, changing its radius with the variation in strength of the current in the coils. This is something to arouse the enthusiasm of the operator and create a desire to investigate this wonderful phenomenon more fully.

This apparatus suggested by Prof. Ralph P. Winch of Williams College and put out by Welch Scientific Company.

For Mathematics

Traditionally, geometry has been studied as a system of rigid, non-flexible elements. These flexible models bring a new approach to the geometry class. Many properties and relationships involving angles, sides, angle bisectors, medians, altitudes and segments terminated by the sides can be discovered and verified. By using two or more triangles, patterns of congruence and similarity can be studied. The use of these models makes geometry a laboratory science. Except for the protractors and graduated arms on the circle, the models are made of durable aluminum colored according to an easily-learned color-code.

This was designed by John F. Schacht, Bexley High School, Bexley, Ohio and manufactured by Welch.

A New Chart

This was put up by the Welch Company and is furnished free on request. It was designed by Dr. Herta R. Leng of Rensselaer Polytechnic Institute and shows the radio active elements Thorium, Neptunium, Uranium, and Actinium.

A NICKEL PROJECT IN CHEMISTRY

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Part I

Purpose: To find out how Uncle Sam made his "war nickels."

Method: Each pupil must obtain a "war nickel." (These will all have Jefferson's head on the front and a replica of Monticello on the back, and *They must have a capital P* (for Philadelphia) or *a capital S* (for San Francisco) or *a capital D* (for Denver) on the back, over the dome of Monticello. These are the three cities which have United States mints.

Clean, dry, and weigh your nickel to the nearest milligram (if your balances and weights are that accurate) and record the weight in your note book.

Now put the nickel in a 300 ml flask and take it to your teacher at the fume closet. Here the teacher will add 15 or 20 ml of concentrated nitric acid (preferably C.P.) and put the flask on a wire guaze over a Bunsen flame (support it on a tripod or a large ring of a retort stand). *Caution: the fumes consist largely of nitrogen dioxide and are extremely bad to breathe.*

As soon as the reaction has become well started remove the flask from over the flame and place it in the back of the hood to continue to react until the nickel has completely disappeared. Be sure to put an identifying mark on the ground glass spot on the flask before you start the experiment so that you can pick out your own flask when the reaction is over. It may be necessary for the teacher to add nitric acid from time to time to the flasks until all the metal has been *oxidized.*

While your nickel is "cooking" obtain an 11 cm high grade filter paper; weigh it to the nearest milligram; fold it, then put it in a long stemmed 60 degree funnel for filtering. Support the funnel over a 250 ml beaker with the tip of the stem just touching the inside surface of the beaker well down toward the bottom of the beaker, so it will not splash.

When your flask is ready get it from the hood and, still holding it in the hood so no fumes will come out, add 15 or 20 ml of concentrated C.P. hydrochloric acid. A heavy curdy white precipitate will form. Continue to add hydrochloric acid as long as more precipitate forms.

Next take the flask to your own place. Holding it by the neck swirl the flask gently to make the precipitate whirl around and around in the bottom. This will cause the precipitate to gather together in curds and make filtration more rapid.

Obtain a stirring rod long enough to reach the bottom of the flask and slip a one inch piece of small pure gum rubber tubing over one end until only a quarter of an inch is left hanging over the end. This is called a "policeman" in laboratory language. It will go after and bring in the very least particle of precipitate if used skilfully during the filtration.

Now transfer every bit of the precipitate from the flask to the filter paper, washing it well down into the tip of the filter. Since your flask will still have a lot of precipitate in it after the first attempt to transfer the precipitate pour back into the flask some of the filtrate now in the beaker and swirl it around thus getting all of the remaining precipitate down into the bottom of the flask and again sweep the precipitate out into the filter using the policeman to urge on the little particles that stick to the glass. Continue until there is no precipitate remaining in the flask.

Next wash the precipitate in the filter by adding small amounts of distilled water from time to time and letting it drain well out before adding the next wash water. Continue until the last drop on the tip of the funnel has no taste.

The next thing to do is to dry the filter paper and precipitate thoroughly, preferably in a drying oven set to hold a temperature of 105 degrees centigrade. If such an oven cannot be had dry the filters near a radiator or in a sunny window sill.

When thoroughly dry remove filter paper and precipitate to a "tared" watch glass (one that you have already weighed) and get the weight of paper and precipitate. Record in your note book.

Subtract the weight of the dry filter paper from the weight of paper and precipitate and thus get the weight of the precipitate.

This precipitate is really *silver chloride*, Ag Cl. Using the atomic weights of both silver and chlorine calculate what part of the weight of the precipitate is *real silver*, thus

$$\begin{array}{cc} \text{Ag} & \text{Cl} \\ \end{array}$$
$$107.88+35.46=143.34.$$

Therefore 107.88/143.34 of the total weight of your precipitate is silver. Probably all the silver used in the "war nickels" came from the West Point store and, since by act of Congress our government is compelled to pay 92 cts per Troy ounce for all silver produced in the United States, figure what the silver in your nickel probably cost the government. You will then see why all the "war nickels" were mint marked (P or S or D). They can now be "retired" and refined and the silver put back at West Point.

Find from a current newspaper the price of foreign silver (right

around 73 cts per Troy oz) and calculate the cost of the silver in your nickel if of foreign origin. Note there are 480 grains in a Troy ounce and there are 15.43 grains in a gram. You can now find what part of a Troy ounce the silver in your nickel was.

Part II

Purpose: To actually get the metallic silver out of the precipitate of silver chloride and to weigh it by itself and thus to check on the accuracy of your previous calculation.

Method: Transfer every bit of the silver chloride from the filter paper to your beaker and add about 50 ml of dilute hydrochloric acid (1 to 5). Then add five to ten grams of granulated zinc (or mossy zinc). Put the beaker (identified) into the gas hood and let the zinc displace hydrogen from the acid. Between them the hydrogen and the zinc will also displace silver from the silver chloride precipitate. This is called reducing the Ag Cl. Because of the extreme insolubility of the silver chloride this will be a slow task. From time to time look at your flask and if either the zinc or the acid has given out add more of the one which is lacking. Continue until all the white silver chloride has been changed to gray finely divided metallic silver. Remember that "Rome wasn't built in a day." When you are sure that no more unchanged silver chloride remains add more hydrochloric acid as long as any zinc remains.

Now transfer your silver "mud" to a tared filter paper (much as you transferred the silver chloride to the filter paper). Get every bit of the silver well down toward the point of the filter. Wash repeatedly with small successive additions of distilled water. Dry in the 105 degree oven and weigh. Subtract the weight of the paper and you will have the weight of your silver. How near did it come to the estimated weight of part I? If you have a blow torch or an acetylene torch available transfer all the silver from the paper to a "bone ash cupel." (Used by assayers to cupel silver and gold. Can be had from chemical supply houses) and add a little borax glass to hold it together and melt it down into a "button" of silver. Keep it as a souvenir of this experiment.

Part III

The teacher may well test some of the filtrate from one of the first flasks by adding concentrated ammonia gradually, calling attention to the formation of the pale blue insoluble copper hydroxide, followed, on adding an excess of ammonia, by the formation of the deep blue copper ammonia ion $Cu(NH_3)_4^{++}$ a delicate test for copper.

The class may then be shown a test for nickel using a known nickel salt (Use the dimethyl glyoxime test) and then some more of the orig-

inal nitric acid solution may be tested for nickel (Not a trace can be found. Nickel had gone to war).

A further test will show the presence of cadmium in the alloy. (Neutralize, add KCN, then H_2S) to precipitate CdS without precipitating CuS.

Part IV

If the school has a class in quantitative analysis a complete quantitative analysis of one of these war nickels will show that they consist mainly of copper with about 36% of silver and 6% cadmium. This alloy gives to the nickel the right weight to operate "nickel-in-the-slot" machines; it has sufficient malleability to strike coins well, and is otherwise suitable for the purpose. It does, however, tend to tarnish rather badly.

The regular nickels, whether Jefferson or buffalo or with the liberty head are of copper-nickel alloy (75% Cu and 25% Ni).

Prewar Canadian nickels were of pure nickel. (Try a magnet and see it pick up such a nickel.)

Thus we see that we can learn a lot of chemistry—and "all for a nickel."

FIFTY YEARS OF TEACHING SCIENCE AND MATHEMATICS

Our anniversary book is now rapidly advancing from manuscript to book. It has been with the printers for over a month. The folder showing in miniature the color of binding and the cover design has reached you some weeks ago. The Promotion Committee mailed out 3500 copies. You can be of distinct aid to the success of the great undertaking by ordering the book now.

Every library should have and will no doubt be anxious to add the book to its collection. Will you inform your school and city librarians of the reduced advance order price? We might also plan to give the book as a Christmas gift to teacher friends of ours.

The Promotion Committee was much pleased with the response from the members who attended the Chicago convention banquet last November where 50 per cent of the members placed an order for the anniversary publication.

We remind you again that the pre-publication price of the book is \$2.50, after September 1, 1950 the regular price of \$3.00 will prevail.

The Promotion Committee

RADIOISOTOPES IN BIOLOGY*

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Man has exhibited constant interest and curiosity about the physical structure and mechanics of his own body and the living things in his environment. The theorists, scholars and experimentalists have gradually worked out many fundamental biological concepts. The scientific methods employed by the life scientist in arriving at our present-day understanding of living matter are a direct outgrowth of his intelligence, perseverance and the research tools available for application to the problems at hand.

In the 17th century the invention of the microscope gave a great impetus to the study of living matter. The microscope provided the life scientist with an instrument which allowed the observation of minute single cells, either free-living or as integral parts of tissue. This more intimate view into the make-up of living substances made it necessary for the early biologist to reevaluate his concepts of the organization of living things. This marked the beginning of our understanding of the importance of the individual cell and its relation to the whole organism, creating the sciences of histology and cytology.

In the 20th century the discovery of isotopes presents a new tool whereby the biologist can explore the physiology and biochemistry of organisms in the dynamic state with greatly improved vision. As the microscope permitted the examination of structural details of individual cells, isotopes allow observation on the chemical activities of individual batches of atoms, ions and molecules within cells and organisms. This fine perception permits a reevaluation of present day concepts and an extension of our knowledge.

Isotopes are atoms with identical chemical properties but different atomic weights. The term includes both the stable and radioactive nuclei of a particular element.

Figure 1 diagrams the nuclear structure of the isotopes of hydrogen and carbon. All the members of the carbon family, for example, contain 6 protons[1] in the nuclei of the atoms and 6 electrons[2] in the orbits of the atoms. The number of protons fixes the atomic number (or the position in the periodic table) and establishes chemical properties and behavior of the atom. However, the five nuclei of the carbon isotopes have from 4 to 8 neutrons;[3] the variations in the number of

* Presented at the Biology Section of the Central Association of Science and Mathematics Teachers, November 25, 1949.

[1] The proton is a positively charged particle of matter having mass of approximately 1.6725×10^{-24} grams.

[2] The electron is a negatively charged particle having masss of about 1/1840 of a proton.

[3] The neutron is a particle of matter with no electrical charge and a mass slightly larger than a proton.

neutrons account for the physical properties of the atoms.

An appreciation of the relative size of the atom and its parts may be obtained from the following: An ounce of tissue contains something like ten thousand trillion, trillion (10^{22}) atoms. Even the national debt is submicroscopic by comparison. A man of average height is 10,000 times taller than the diameter of the red blood cell. The diameter of the red blood cell is 100,000 times the diameter of an atom. The diameter of the atom is 40,000 times the diameter of its nucleus.

In all their smallness, atoms exhibit finite structure. An atom, in a sense, is like a small solar system with the nucleus representing the sun and the electrons behaving as the sun's planets. The nuclei of all atoms are made up of a definite number of neutrons and protons. These nuclear particles are of about the same mass or weight, but the proton has a positive electric charge while the neutron has no charge at all. Revolving around the positively charged nucleus are a definite number of whirling, negatively charged electrons with a mass of approximately 1/1840 of a proton. The attractive force between the negatively and positively charged particles helps to hold the atom together in much the same manner as the force of gravity holds the universe in place.

Carbons 12 and 13 are stable isotopes as shown in Figure 1 and occur in nature at the ratio of 99 to 1. Carbons 10, 11 and 14 are unstable, man-made atoms which give off ionizing radiations like radium when they disintegrate and are known as radioisotopes. Disintegration as used here denotes a change of one atom to another of different chemical or physical properties. The manner of disintegration, length of existence and characteristics of radiation are physical properties which help to identify the radioisotope. The properties associated with a particular isotope are established at its formation and there is no known method of changing them without modifying the structure of the nucleus.

The instability of radioisotopes is caused by an over abundance of energy within the nucleus. This excess energy is given off in the form of radiations. Most of the biologically useful isotopes emit beta particles (an electron originating in the nucleus) with or without gamma rays (an electromagnetic radiation akin to X-ray).

In the case of carbon 14, the radiations are beta particles of low energy. Carbon 11 gives off positrons, in a sense positively charged betas, which change themselves into gamma radiations. When these radiations pass through matter, they produce ion pairs or charged particles. This phenomenon enables the scientist to detect the occurrence of the disintegrations. All the apparatus used for detection of radioisotopes are based upon the formation of ionized particles

and the measurement of the degree of ionization. These instruments have taken the form of the Geiger-Mueller counter, the ionization chamber, and other electronic devices.

Because radioactive atoms give off these radiations wherever they go, one is able, with proper instrumentation, to follow the atoms as they pass through biological and chemical systems. Furthermore, radioactive atoms are indistinguishable from their inactive counterparts in practically all physical, chemical and biological situations until radiation is emitted. These properties are the basis of the radioisotope technique, whereby one can trace the movements of atoms or tag a material of interest in the biological system.

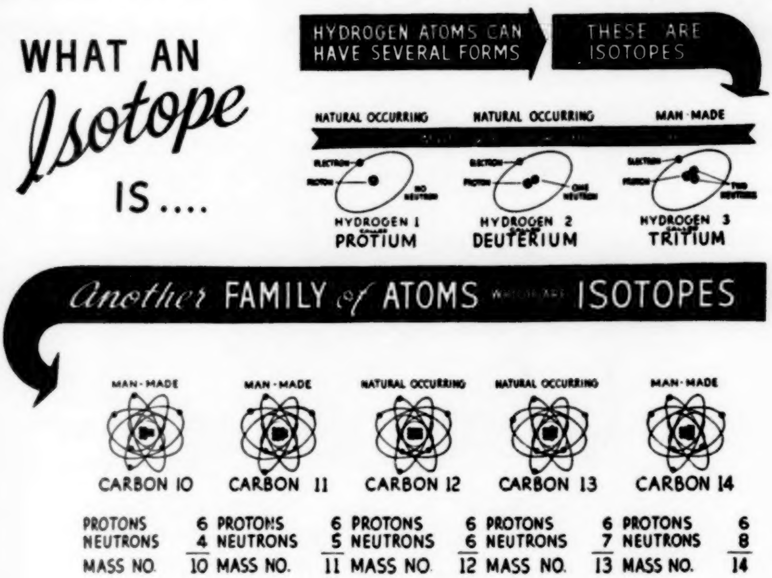


FIG. 1

In addition to the characteristic radiations that arise from the radioisotope, the half-life is another significant means of identification. The term, half-life, is a measure of the length of usefulness of the isotope. The disintegration of radioactive atoms is a random affair but it can be measured in terms of the time in which half of the radioactive atoms in a given batch will disintegrate. Given a sufficiently large number of atoms of a particular kind, this length of time can be ascertained accurately. Figure 2 is a curve showing the percentage of a batch of radioatoms remaining at successive half-lives.

The half-lives of radioactive isotopes show great variation. The physicist has been able to measure radioisotopes with half-lives of a millionth of a second and with half-lives of ten million years (10^8).

No doubt radioactive atoms with half-lives shorter and longer than those above will be found when techniques of measurement are further refined.

Of course, those isotopes whose half-lives are particularly short do not lend themselves to the study of biological problems. It is fortunate that most of the common elements have half-lives within the range of biological usefulness, that is, those in the order of 12 hours or more. As shown in the earlier slide the half-life of C 14 is in the order of 6000 years while tritium has a half-life of about 12 years.

Radioisotopes occur as constituents of radioactive elements in nature, or may be made by the bombardment of the stable atoms of elements with nuclear particles or light weight ions. Prior to the development of the present day atomic energy program, radioisotopes

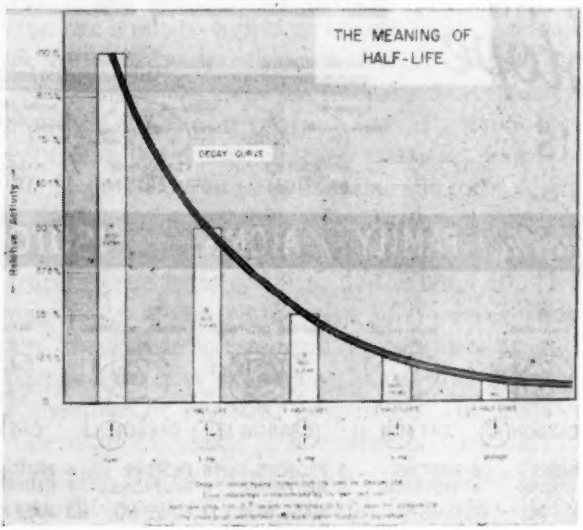


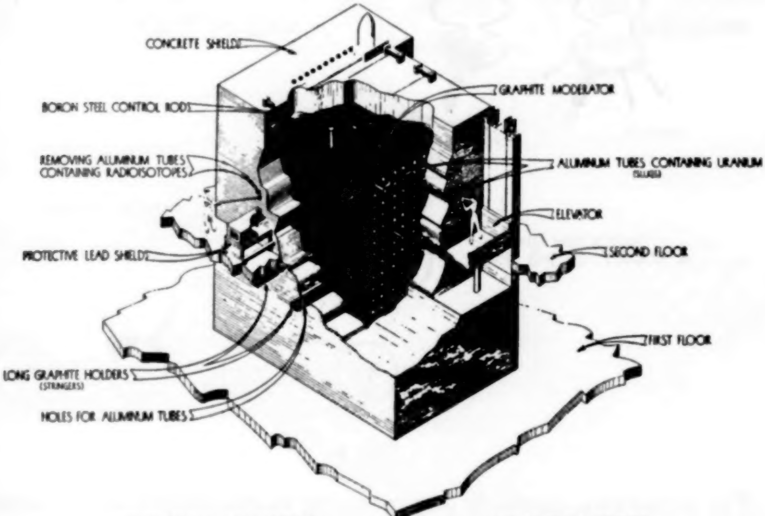
FIG. 2

were produced by cyclotrons and other particle accelerators. These atom-smashing machines are expensive and their operation is tedious and time consuming. The quantities of radioactive isotopes available from such sources are extremely limited and very costly. These machines, consequently, were not and are not able to supply the radioisotope demands of science.

With the discovery and successful operation of the uranium reactor with its intense neutron flux, radioisotopes can be made in quantities millions of times greater than could be produced in the particle accelerators.

It may be of interest to describe briefly the construction and operation of the uranium reactor (presented schematically in Figure

3). The functioning part of the reactor is encased in a thick concrete wall which protects the workers from the intense harmful radiations being produced. The interior of the reactor is made up of blocks of graphite, with rods or slugs of uranium impregnated within its interior. It is in this portion of the atomic furnace that the fissioning and energy generating reaction takes place, and neutrons in copious quantities are released. Some of the neutrons are used to "trigger" the splitting or fission process in new uranium atoms while other neutrons are used to produce radioisotopes. If enough uranium is present, the fission reaction is self-sustaining. Since the chain reaction is characterized by this property, control mechanisms are necessary to prevent levels of activity which might prove hazardous. The boron steel rods depicted at the top of the diagram are capable of absorbing



NUCLEAR REACTOR —— URANIUM "PILE"

FIG. 3

neutrons. By inserting or withdrawing the boron rods, the neutron flux (density of neutrons) of the pile may be controlled. In the Oak Ridge reactor the neutron density is in the order of 10^{12}, or million million neutrons flowing through a square centimeter each second. The volume in which this density exists is larger than a box car.

The uranium reactor may be employed as a source of power, as a research tool, and as a producer of radioisotopes. We are concerned here with the last of these functions.

Radioisotopes are usually made in the uranium pile by one of three methods: (1) The splitting of uranium atoms into different atoms, commonly called fission products; (2) the conversion of stable

atoms into heavier isotopes of the same element; and (3) the transmutation of stable atoms into isotopes of a different element.

Figure 4, diagrams a fissioning uranium atom and shows the formation of fission products. The fission fragments may be extracted from the spent uranium metal and purified by chemical means. Radioisotopes of some 35 elements ranging from zinc to the heavier rare-earths may be isolated in this manner. The most biologically useful radioisotope from this source is radioiodine (I 131).

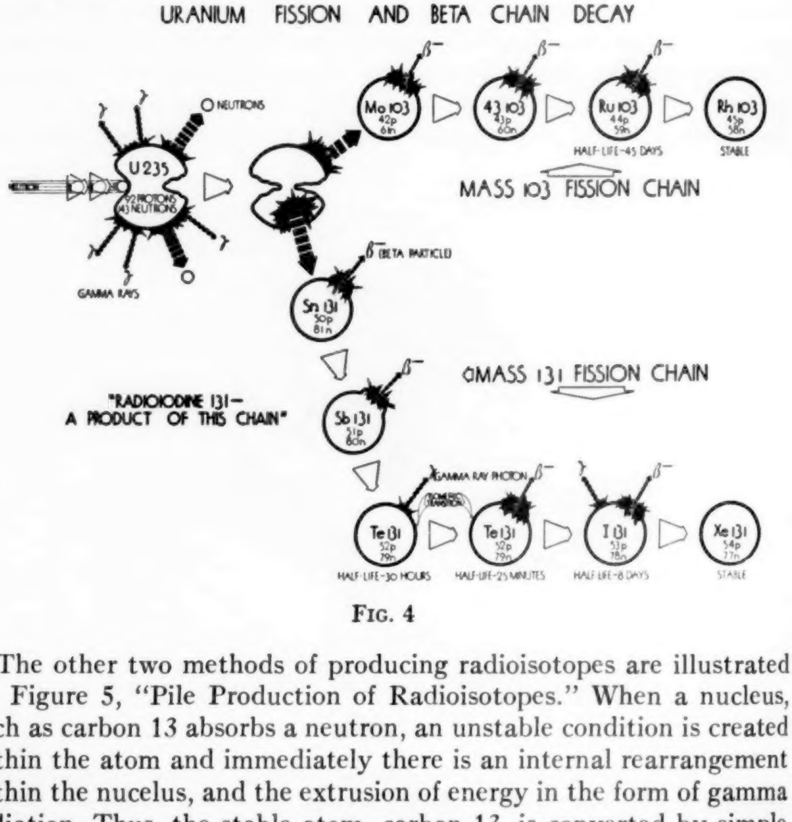


Fig. 4

The other two methods of producing radioisotopes are illustrated by Figure 5, "Pile Production of Radioisotopes." When a nucleus, such as carbon 13 absorbs a neutron, an unstable condition is created within the atom and immediately there is an internal rearrangement within the nucelus, and the extrusion of energy in the form of gamma radiation. Thus, the stable atom, carbon 13, is converted by simple neutron absorption into a radioactive form, carbon 14. The nucleus of this new radioactive atom contains 6 protons and 8 neutrons as opposed to 6 protons and 7 neutrons for its stable predecessor. Carbon 14 disintegrates to a ground or stable state by the expulsion of a beta particle and transmutes into the atom, nitrogen 14. In like fashion normal phosphorus, P 31, may be changed into phosphorus 32, which is radioactive. The phosphorus 32 atom disintegrates or decays by the emission of a beta particle and arrives at the stable state as sulphur 32. We have now seen how it is possible to convert a stable

element into a radioactive form of the same element by the absorption of a neutron.

In other cases neutron bombardment will result in transmutations of the elements. The reactor irradiation of atoms such as nitrogen 14 will initiate the simultaneous extrusion of a proton which reduces the atom to the next lower position in the atomic table. Therefore, carbon 14 may also be made from nitrogen 14. As previously pointed out, carbon 14 decays by the emission of a beta particle back to stable

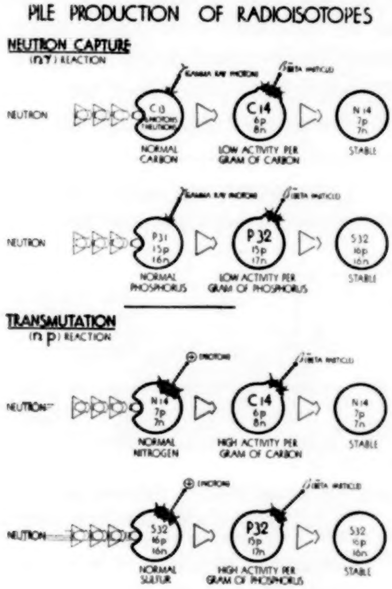


FIG. 5

nitrogen 14. Similarly, the nucleus of sulphur 32 will accept a neutron and extrude a proton, thereby being transmuted into radioactive phosphorus. Radioisotopes produced by this method may be separated chemically from the parent material. Samples so separated will contain very high activity in a very small mass. Such samples are said to have a high specific activity (ratio of activity to mass). Samples prepared by the method described in the preceding paragraph always have a low specific activity. Frequently high specific materials are very advantageous to the biologist, especially where only small traces of material can be used in experimental animals.

The availability of large quantities of many biologically significant elements from the nuclear reactor permits a direct approach to important problems associated with the dynamic state of living matter through isotope or tracer research. The remainder of this paper will be devoted to a brief résumé of the manner in which these materials

are being employed by the biologist. Space will not permit an extensive coverage of these applications because they are numerous in all fields of biology.

Radioactive atoms are being used as scientific detectives to study the rates at which various ions and molecules traverse the membranes and tissues of the body. Figure 6 illustrates the use of radioactive sodium (Na 24) to study the sodium turnover in the body. Radiosodium in the form of saline solution, is injected into the subject. Since Na 24 gives off gamma radiation, the administered batch of sodium atoms can be followed externally with suitable radiation detecting equipment, or detected from samples of blood, plasma, sweat or tissue. Through this procedure we are able to follow the movements of injected sodium even though the body system contains

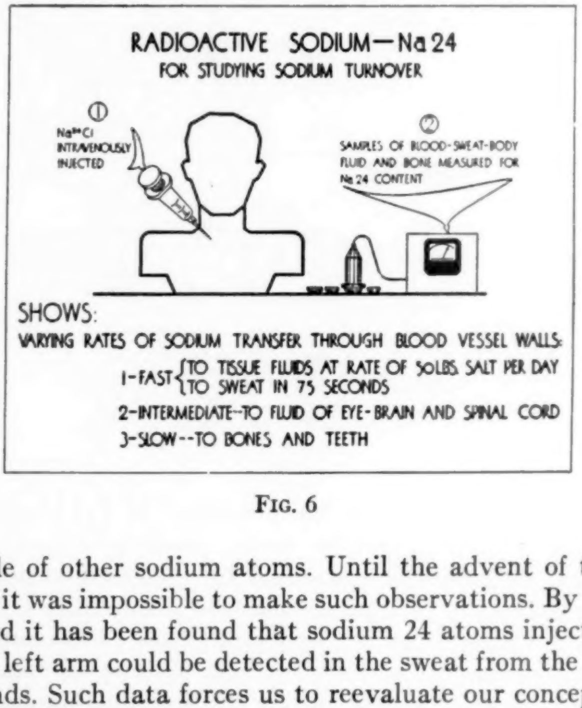


FIG. 6

a multitude of other sodium atoms. Until the advent of the tracer technique, it was impossible to make such observations. By the use of this method it has been found that sodium 24 atoms injected into a vein of the left arm could be detected in the sweat from the right arm in 75 seconds. Such data forces us to reevaluate our concepts of the dynamics of living things.

Radioactive sodium has also been used in the study of the efficiency and congestive conditions of the heart and peripheral circulatory difficulties. This radioisotope will also supply answers on the behavior of sodium in the body as well as its relation to total body water, the intercellular fluids, and the blood.

Studies with radioactive potassium have paralleled closely those investigations previously described using radioactive isotopes of

sodium. Since potassium is one of the most important alkali substances in body cells, and its replacement is essential to the building of new tissue, an understanding of its action is obviously quite important. With the production of an artificially radioactive isotope of potassium (K 42), a new method of attack upon problems associated with the metabolism of this element has become available.

Studies of this nature are exemplified in Figure 7. This new technique has been employed to measure the magnitude and rate of total exchange of potassium across cell membranes. The rate of transfer of potassium ions has been shown to be quite low. In contrast to this, related studies with sodium 24 indicate that the sodium ion traverses membranes rapidly. These investigations are supplying us with information not previously available regarding the amount of potassium and sodium lost by disease and the quantity needed for replacement to restore normal health.

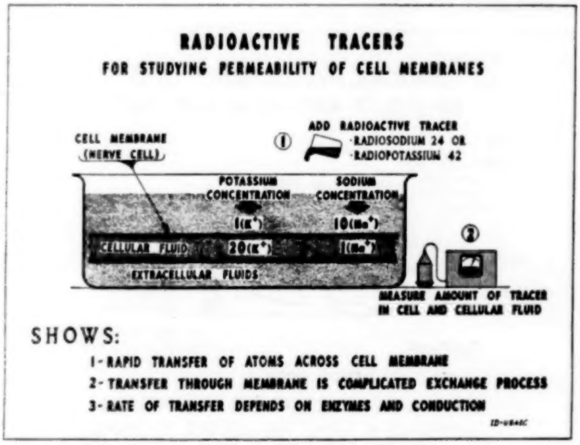


FIG. 7

Another very interesting physiological study has been carried out with phosphorus 32. This study has shown that many organic compounds in animal tissue formerly thought to be comparatively fixed are actually undergoing continued molecular decomposition and resynthesis. Such dynamic characteristics have been demonstrated for brain tissue. Using phosphorus 32 as a tracer it is possible to estimate the rate of turnover of phospholipids in different tissue at various periods after ingestion of labeled sodium phosphate by the animal. The data as reported indicates that the rate of turnover in brain tissue is lower than the liver, kidney, or small intestine. This study also revealed that the rate of phospholipid turnover was greater in young animals than in old, decreasing quite rapidly from birth until

the animal reached its adult weight, and then more slowly thereafter. Here, very neatly, the tracer method has verified the hypothesis of dynamity. Therefore, we must regard living things as dynamic entities in which every part of the organism, down to the most minute portion of each individual cell is in a continuous state of molecular and ionic flux—entities devoid of fixed structures, which exhibit form only as a temporary expression of equilibrium states in which the flow of ions and molecules assume definite paths.

The proceding illustrations show that atoms and simple ions may be traced and studied in a biological system. However, the biologist encounters many complex compounds. If we can incorporate a radioatom into the molecule, studies can be performed on these more complex units. Figure 8 illustrates a study of amino acids labeled with radioactive sulphur (S 35).

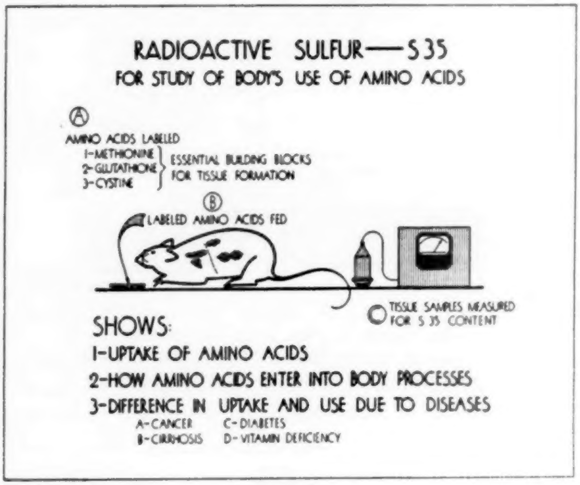


FIG. 8

In addition to the study of molecules as a unit, fragments of molecules produced by body action, can also be followed, provided the position of the radioactivity in the molecule has been determined. Many chemicals have long been recognized as cancer or tumor producing agents but little has been known about the actual behavior of the chemicals in the tissues. Frequently, the quantities of materials required to produce tumors are so small that usual analytical techniques are not satisfactory. However, due to the extreme sensitiveness of radioisotope techniques, many experiments, such as the one described in Figure 9 can be performed. It is not necessary to have a part, or even a hundreth of a part per million to do satisfactory work. The isotope technique has been employed to study the occurrence of materials in a millionth of a part per million.

Radioisotopes have been applied in studies of domestic animals in an attempt to test the physiological availability of certain elements and to follow their metabolic pathways. Due to the sensitiveness of

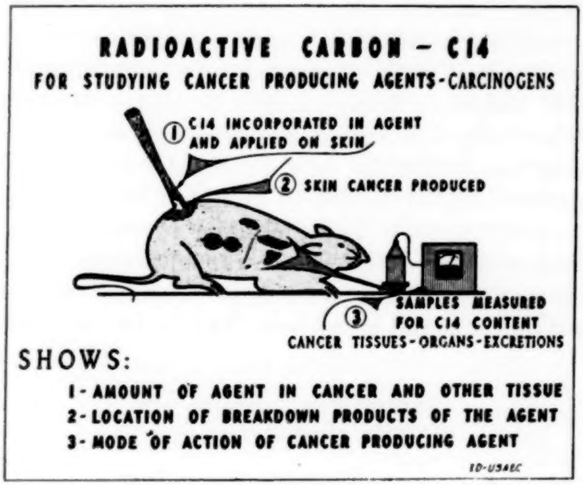


FIG. 9

the tracer technique noted earlier, radioisotopes are especially useful in the study of trace elements. Figure 10 illustrates the application of the radioisotope, cobalt 60, to study a deficiency disease in livestock.

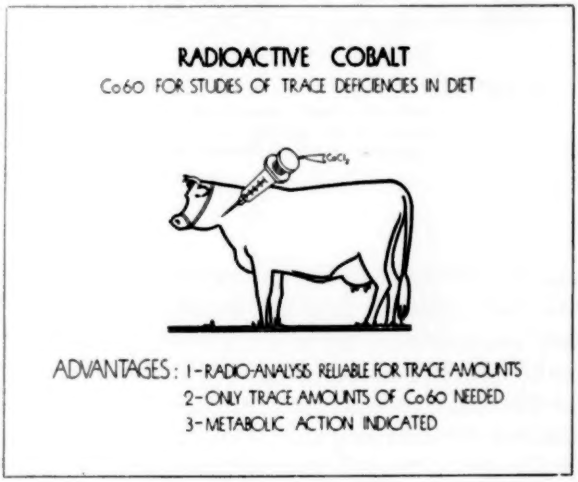


FIG. 10

Coast Disease, Pine Disease, and Bush Sickness in sheep, and Salt Sickness in cattle have been associated with areas seriously deficient in cobalt and have been reported in Florida, Michigan, Massachu-

setts, Wisconsin, New Hampshire, and North Carolina, as well as areas outside the continental United States. When cattle and sheep are fed on forage containing less than four parts of cobalt in 100,000,000 they suffer a loss of appetite and are literally starved to death, although surrounded by luxuriant growth of pasture. Animal metabolism of cobalt in these areas are of extreme interest.

The tracer technique using radioactive cobalt is very applicable due to the extremely small amount of cobalt consumed in metabolism. Studies using this technique fixed the minimum of cobalt essential for the maintenance of health in ruminate animals. The present findings support the view that the major function of cobalt in the ruminate is a localized action in the rumen and indicates the possibility of a hematopoetic function which is probably catalytic in nature as indicated by the small amount of the element involved.

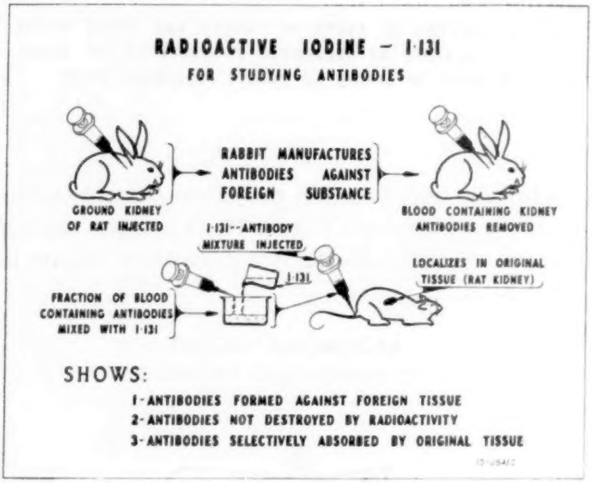


FIG. 11

Biological substances more complex than molecules have been tagged with radioisotopes and employed successfully in securing specific data unobtainable by other known methods. An excellent example is the use of radioiodine-labeled antibodies. In the past, the biologist in his effort to elucidate the *in vivo* activity of antibodies has been limited to observing the physiological or cytotoxic effects. Now, with the use of tagged antibodies, specific locations of action can be determined and some insight of the activity can be gained in animals with near normal physiology. Figure 11 illustrates a procedure which has been followed.

To prepare the labeled antibody, an emulsion of blood-free rat kidney is injected intra-abdominally into rabbits. The antiserum pre-

pared against the rat-kidney tissue is extracted from the rabbit's blood. The globulin fraction of this serum is separated and iodinated with radioactive iodine, I 131. The radioactive globulin fraction is then injected into the rat. The degree of localization of the antibody can be measured by the radioactivity in various parts of the body. This technique has shown that when antiserum prepared in rabbits against rat-kidney tissue is injected back into the rats there is a decided accumulation of material in the kidney. It has further been shown that the localization of the anti-kidney serum is due to a specific substance, presumably an antibody from the antiserum, and is not due to a cytotoxic effect of the anti-kidney serum.

In addition to tagging complex biological substances, entire cells have been traced by the radioisotope technique. Figure 12 illustrates a unique manner in which radioisotopes of iron (Fe 55, 59) aided the

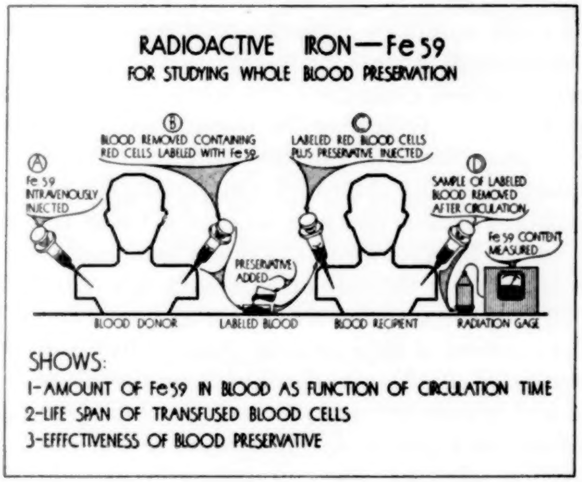


FIG. 12

development of effective ways of preserving whole blood by labeling red blood cells. World War II focused acute attention on the problem because of the great need for whole blood transfusion on the battlefield, aboard ship, and in emergency hospitals at distant points from this country. Under these conditions, whole blood must withstand longer preservative periods and yet be viable upon transfusion. It was imperative that an accurate method for measuring the post-transfusion survival of stored human erythrocytes be developed before preservative methods could be evaluated.

Radioactive iron became the tool for this evaluation. A small amount of radioactive iron salt is given intravenously to a blood donor. The salt is removed from the plasma and deposited in body

iron stores. In the process of erythrocyte formation in the marrow, some of the iron atoms that become incorporated in the hemoglobin molecules of developing cells are radioactive. It is pointed out that since hemoglobin does not diffuse from the normal erythrocyte, it follows that as long as this tagged red cell remains intact, their presence may be detected. If these cells are destroyed, the released radioactive iron returns from the plasma to the iron stores, and will be reutilized and resynthesized into hemoglobin, and will again appear in new red cells. However, the time required for this cycle is so long that the newly formed erythrocytes will not materially affect the test described in the following paragraphs.

Blood containing the tagged red cells is removed from the donor by exsanguination and mixed with the preservatives to be tested. The preserved blood mixture is then stored under various conditions for varying lengths of time or, as during the wartime investigations, shipped to distant points to duplicate field conditions and then returned to the research centers for testing.

The preserved blood containing the labeled cells is then injected into the test recipient. Following the transfusion, red blood cells are removed at appropriate intervals from the recipient and measured for their radioactivity to determine the percentage of cellular survival. Diminishing radioactivity in successive blood cell samples indicates the rate of breakdown of the donor cells and their loss from the circulation. During the war an arbitrary rule was adopted that survival of 70% of the transfused cells for 48 hours would be acceptable and that survival of 90% or more of the cells would indicate excellent preservation. In this way the maximum useful life of preserved whole blood was determined and methods developed for extending it.

Of immediate and practical importance is the direct approach which radioiodine affords to the correlation of thyroid cells to iodine metabolism. This is achieved by the autoradiographic technique, illustrated by Figure 13. Radioiodine is administered and allowed to be accumulated by the thyroid. After removal, sectioning and preparation of the gland for microscopical study, a photographic emulsion is placed on a section of the tissue. The radioiodine will act upon the emulsion which can be developed in contact with the sectioned tissue. The tissue section and the emulsion can then be viewed microscopically. The histology of the cells of the section can be correlated with the iodine uptake by simply using the fine adjustment of the microscope.

Radioiodine has also demonstrated its usefulness in the diagnosis of thyroid disorders. It is well known that the thyroid can concentrate iodine at a level 5–10,000 times that of blood. It is possible to introduce orally into the body a small quantity of the radioiodine,

called the tracer dose, and determine with accuracy the predilection of a particular thyroid disease for radioiodine by radiation measurements. This affords the diagnosing physician a tool for ascertaining in a fairly qualitative manner the behavior of the thyroid gland. Similarly, offshoots of a cancerous thyroid can be located in other parts of the body. This procedure is shown in Figure 14.

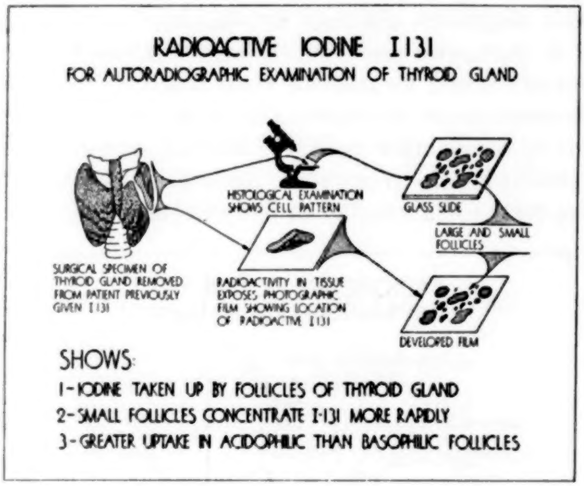


FIG. 13

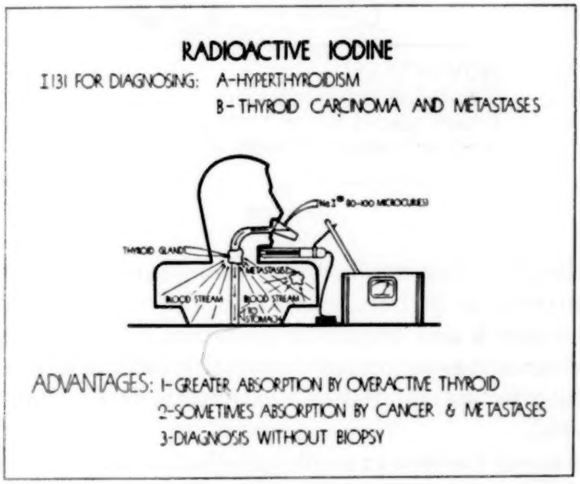


FIG. 14

Another striking diagnostic technique is the use of radioactive iodine as a complement to the dye, fluorescein, in the detection and localization of brain tumors. The technique is depicted by Figure 15.

It has previously been demonstrated that fluorescein exhibits some selective localization in tumorous brain tissue. Because of its fluorescence under ultra-violet light, the dye has aided the surgeon in locating tumor masses during surgery. However, this technique is limited because it does not provide external evidence of the tumor site.

Recently the use of radioactive (I 131) diiodofluorescein has been reported for locating brain tumors. The radioactive dye is a particularly effective diagnostic aid since the fluorescein guides the material to the site of the tumor and the radiations of the I 131 enables the external detection and location of deep seated intracranial tumors.

The aforementioned examples are representative of diagnostic applications of radioactive isotopes. Studies such as these are only beginning, but it is safe to say that, in time, they will lead to important routine tests for a number of body impairments and diseases.

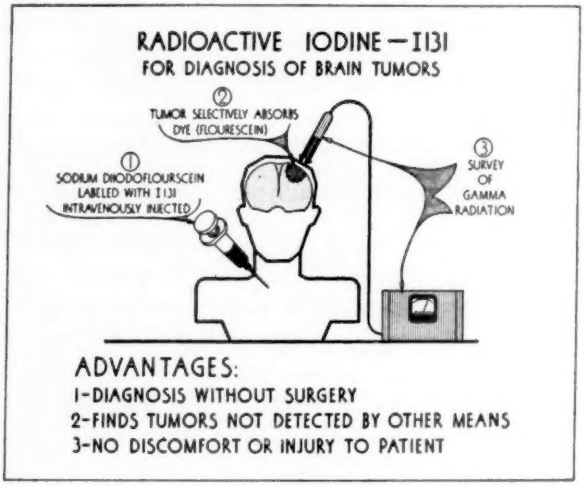


FIG. 15

All of the preceding applications show radioisotopes as informers on the movements of ions, molecules and complex substances in biological research and diagnostic problems. However, radioisotopes are also being used as sources of therapeutic radiation, where selective accumulation by specific tissues concentrate large quantities of the radiomaterial.

Perhaps one of the best examples of selective localization in therapy is that exhibited by radioiodine. Because of the extreme avidity of the thyroid for iodine the physician is able to deliver large doses of radiation by means of radioiodine to the overactive thyroid. The radiations from the disintegrating iodine effectively curb these malfunctions in most cases. Radioiodine has, for instance, been found to

provide a simple, effective and apparently safe method for treating patients with hyperthyroidism. Certain types of goiter also respond to iodine therapy. Limited success has been observed in controlling cases of thyroid cancer, treated with iodine 131.

Another radioisotope, radioactive phosphorus (P 32) has been used in the treatment of polycythemia and leukemia, as pictured by Figure 16. Symptomatically, polycythemias are characterized by an unhealthy number of red blood cells, while leukemias show an alarming increase in the number of white blood cells. Radiophosphorus is selectively absorbed by the bone. Since the bone marrow is the primary blood cell forming organ, the radiation of phosphorus 32 is effective in reducing the number of blood cells. The radiations of radiophosphorus penetrate only 5 or 6 millimeters of tissue. Therefore, the bony structures are subjected to high dosages of radiation

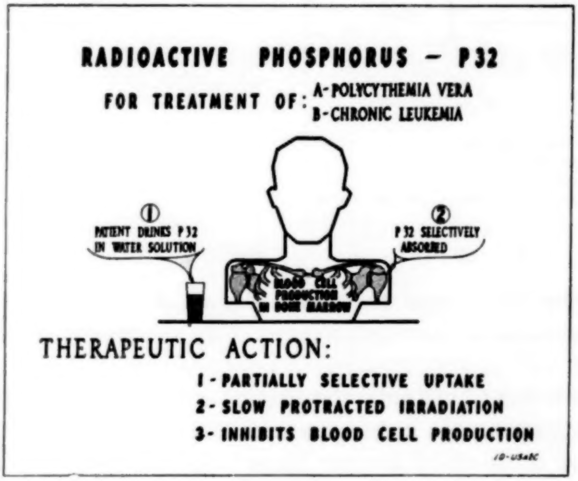


Fig. 16

while the surrounding tissues receive a relatively small amount of injurious radiation.

This treatment has been established by many physicians as the treatment of choice for polycythemia. It has been used with some success in the treatment of chronic luekemia but with little success in the treatment of acute leukemia.

The use of phosphorus 32 and other beta emitting radiomaterials in the local therapy of superficial skin growth is proving beneficial. Properly designed disks containing measured amounts of the active isotopes are applied to the affected skin areas. Very localized therapy is permitted since, as previously noted, the beta radiation from the source penetrates about one-half of a centimeter of tissue. This has

the advantage over roentgen or cathode radiation, in that the limited energy of the nuclear particles avoids the irradiation of deeper tissues not involved by the neoplasm.

Another man-made radioactive isotope which figures prominently in the field of therapy is cobalt 60. When cobalt is made radioactive in the uranium reactor, its radiations are very similar to those of radium. Therefore, it can be used as a therapeutic tool in the same manner as radium. Figures 17 and 18 diagram such application. Cobalt 60, however, has two advantages over radium. At the present it is considerably cheaper; further, it may be prefabricated into any desired shape or size before being made radioactive and is, therefore,

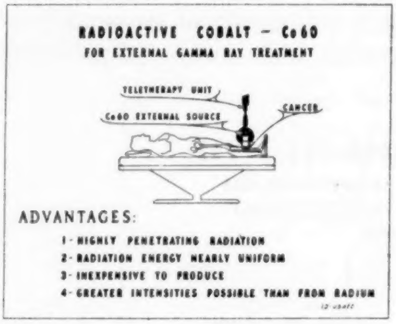


FIG. 17

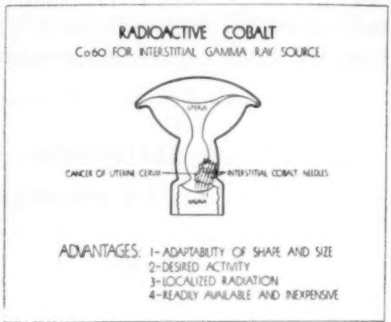


FIG. 18

more flexible in design. However, the mode of treatment is based entirely upon mechanical placement of the radioisotope as in radium treatment.

From this brief look into the origin, activities and applications of radioisotopes, one can not escape the fact that we have a new set of keys—keys to doors of greater knowledge and improved living. We now need the trained personnel with the vision and insight to match the keys with the locks on the doors of progress. Those who will use the keys are in your classrooms and laboratories. The inspiration and training which the science teachers are imparting to the youth of America will accelerate the advent of a brighter future.

INDIANA UNIVERSITY SUMMER WORKSHOP

Indiana University will hold its third annual Workshop for Mathematics Teachers June 19 to July 1. Graduate credit will be given for those who desire it. There will be exhibits, lectures, group discussions and analyses of problems brought in by the members. There will be a shop and instructor available for those who wish to try their hand in making visual aids. Programs will be available about May 1. If you wish a program, please write Philip Peak, University School, Bloomington, Ind.

PHILIP PEAK

SERVICES AND FACILITIES FOR THE ELEMENTARY SCIENCE CLASSROOM

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The University of Chicago, Chicago, Ill.

A frequent complaint made by elementary science teachers concerns their inability to use the demonstration method in a classroom lacking the services and facilities commonly found in a science laboratory or in a room equipped with a demonstration table.

The purpose of this paper will be to show how these services and facilities can be provided, at very low cost, in any classroom. The author will attempt to summarize some of the contributions that have been made in the past towards the solution of this problem, and to suggest one or two procedures that may be unfamiliar to some teachers.

The services and facilities usually required by the teacher of elementary science are the following:

1. A source of water
2. A source of heat
3. Electrical outlets
4. Compressed air and vacuum facilities
5. A large, flat working surface

1. *A source of water.* A reservoir with a capacity of approximately ten gallons, and which serves water through a simple faucet-substitute, can very easily be constructed and installed in any classroom. The first step is to procure a crystal water bottle or other large container, preferably one which can be stoppered. The container should

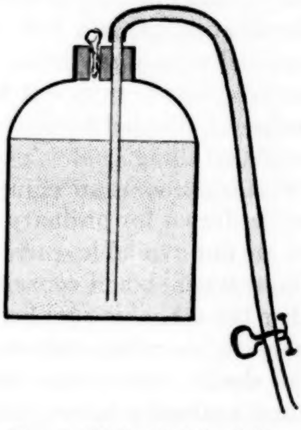

FIG. 1. Water bottle siphon.

be filled with water, and fitted with a siphoning arrangement as shown in Figure 1. The unused hole of the stopper can be loosely plugged with absorbent cotton to keep dust from entering, and yet allow for the entrance of air. The fitted bottle should be set on top of a cabinet at or near the front of the room, or on a shelf built in a corner above the front blackboard. If a shelf is constructed, it should be fitted with side guard walls in order to prevent the container from falling off accidentally. Small amounts of water for test tube demonstrations and other purposes can be obtained from a simple wash bottle. (See Figure 2.) An ordinary galvanized iron utility pail can be used as a waste container.

FIG. 2. A wash bottle.

2. *A source of heat.* The Bunsen burner, or a modification, is probably the most frequent source of heat used by the teacher fortunate enough to have a room equipped with a demonstration table and services for his science teaching. Several arrangements are available for storing illuminating gas in portable gas holders, similar in construction to the spirometer used in physiology. With such a device, a Bunsen burner can be used in any classroom. However, it is felt that from the viewpoints of safety and convenience, a heating device, other than one using illuminating gas as a fuel, should be substituted in the classroom not supplied with a gas outlet. An electric hotplate or a good alcohol burner will provide sufficient heat for most elementary science teaching purposes. Alcohol burners, with wide wicks, can even be used for bending glass tubing.

3. *Electrical outlets.* Most classrooms are equipped with wall outlets from which current can be drawn for ordinary purposes. In the few cases where such outlets are not available, current can be drawn from the lighting fixtures. The teacher should consult with the school janitor to determine whether the school is supplied with a-c or d-c, and then check her apparatus to see what current it is intended to be operated on. In cases of doubt, the teacher should check with the janitor or other competent authority before plugging a device into a classroom outlet.

4. *Compressed air and vacuum facilities.* An ordinary bicycle or football pump can be converted into an all-purpose pump, i.e., it can deliver either compressed air or serve as an exhaust or vacuum pump. The first step in the conversion is to remove the small ball-bearing from the outlet at the bottom of the pump. (See Figure 3.) This can be done by carefully reaming the outlet hole with a large nail until the bearing falls out.

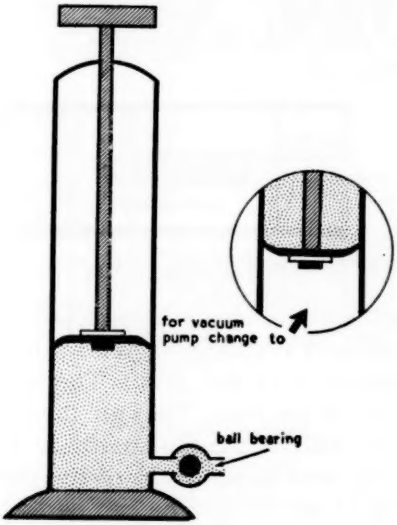

FIG. 3. Converting the bicycle pump.

The second step is to prepare a Bunsen valve*. (See Figure 4.) With a razor blade, a one-inch slit is cut lengthwise near the middle of a short length of rubber tubing. A piece of glass rod is inserted in one end of the piece of rubber tubing, and a short length of glass tubing is inserted in the other end.

The assembled rubber tubing is then enclosed in a large glass tube open at both ends; or in a talcum powder can with the ends removed; or in a plastic vial open at both ends. The last two types are favored because they are not easily broken. The ends of the enclosure are then stoppered as shown.

To obtain compressed air, the left end of the Bunsen valve is attached to the bicycle pump, and the pump is operated in the normal fashion.

To use the pump as a vacuum pump, it must be opened and the screw holding the piston and washer removed. These parts are then removed from the shaft, and replaced so that the piston cups upward,

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* Suggested by Mr. Albert Gilman of the Central YMCA High School, Chicago, Ill.

with the washer below it. In this case, the right end of the Bunsen valve is attached to the bicycle pump, and the pump is operated in the normal fashion.

The author has modified the above procedure somewhat in converting a $.39 football inflator (purchased at Walgreen's) to a vacuum pump capable of collapsing a one-gallon can in four or five strokes. The only changes made in the procedure described above were necessitated by the facts that the washer and piston were held in place by friction in this pump, and that the top of the pump was secured by friction to the pump body.

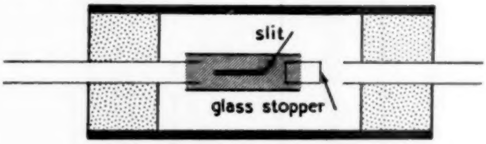

FIG. 4. Bunsen valve.

The first step in this conversion is to cut the body of the pump with a hacksaw about one inch from the top. This will allow the removal of the entire shaft assembly of the pump. The piston and washer are then cut, as a unit, from the shaft. They are then turned upside down, and soldered to the shaft in the new position. The converted shaft assembly is then replaced in the body of the pump, and the top is soldered to the rest of the body. The two parts can also be rejoined in a satisfactory manner with a good grade of one-inch waterproof adhesive tape. In order to make this unit a more compact one, the Bunsen valve can be strapped to the side of the pump body with adhesive tape.

5. *A large, flat working surface.* A very satisfactory working surface can be constructed by using a teacher's desk as a base. The top of the surface should be made of $1\frac{1}{2}''$ wood stock, and should be large enough to cover almost the entire desk surface. The sides of the working surface should be high enough to raise the top so that youngsters in the rear of the classroom can see the entire top easily, but should not be so high that youngsters in the front seats will find it difficult to see the entire top. The height of the sides should be determined by actual test before the working surface is constructed. Usually, a height of approximately six inches will be found satisfactory. The surface should be constructed with front and rear guides (See Figure 5.) in order to reduce play to a minimum. The side supports should be fitted with rubber feet, similar to those found on the bottoms of chair legs, in order to protect the desk surface. The front of the working surface should be left open. This will allow the desk surface to be used for temporary storage while the auxiliary surface is being used. It may

be a good plan to cover the desk with a thin sheet of linoleum whenever the working surface is used.

Some teachers will probably elect to cover the working surface with tempered Masonite, transite, or Formica in order to provide for greater safety and cleaning ease.

The basic surface can be modified in various ways. It can be provided with electrical outlets which can be energized through an electric cord plugged into a room outlet. The surface can also be fitted with several flush plates which will accommodate standard threaded steel rods which can serve as support rods.

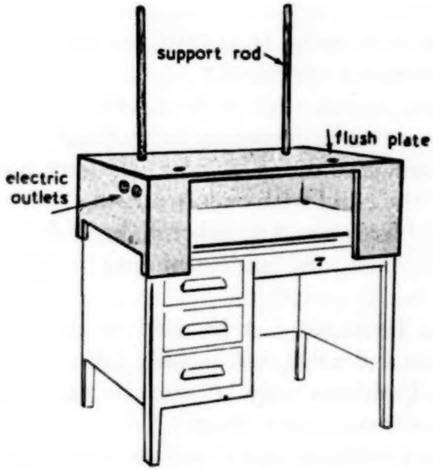

FIG. 5. The working surface.

It will undoubtedly be a great many years before elementary school classrooms are furnished with the services and facilities required for science teaching. As far as the writer knows, the only concession being made in this direction by school architects and builders is to install a sink in each classroom in some new elementary school buildings. It is the writer's view that the simple and inexpensive modifications described herein will help the willing teacher to carry on a successful science program in any present-day classroom.

ERRATA

In our April issue page 337 the publisher of *Principles of Organic Chemistry* by English and Cassidy was erroneously listed as John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16: It should have been credited to McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18. The name of the reviewer was also misspelled. It should have been C. A. VanderWerf.

USE OF ARITHMETIC VERBAL PROBLEMS

SARA RODGERS
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This talk will eplain the use of Verbal Problems at the Burnside School, Chicago under the supervision of our principal Mr. Turner C. Chandler and the cooperation of all the teachers from Grades 4–8. I shall indicate the philosophy and principles of the selection of the problems, the technique of giving the lessons and the follow-up. These lessons, with variations, have been a procedure for many years.

The philosophy underlying the principles involved in the selection and solution of Verbal Problems is:

First, problems should ordinarily involve processes that have been taught. However, to increase the difficulty of the last half of these lessons in some situations new applications of processes may be added to provide the child with experiences he needs in getting a new fact or procedure. Care should be taken to keep these problems within the experience, interest, and understanding of the pupils and based upon significant social situations.

Second, Verbal Problems can be used to show the child that he needs certain facts and processes in daily life.

Third, Verbal Problems may be used in particular situations for practice in the processes being taught.

Fourth, Verbal Problems will illustrate any necessary reteaching.

Fifth, Verbal Problems should be used to teach meanings, not only the meanings involved in the abstract processes, but meanings in concrete situations.

There has been considerable investigation by organizations, committees and individuals in grade-placement of abstract operations in Arithmetic but comparatively little has been done in the way of objective studies in grade-placement of Verbal Problems. Some years ago the Committee of Seven of the Northern Illinois Conference on Supervision, made a preliminary study and came to the conclusion that this topic should be further investigated. Mr. Chandler was a member of this committee and some of the experiments were carried on in our school. Even this preliminary study showed conclusively that the grade-placement of verbal problems cannot be determined very accurately by subjective methods, and so the selection of problems must be done with a great deal of care and never extemporaneously.

At the Burnside School each teacher in Grades 4–8 has at least one lesson each week consisting of sixteen Verbal Problems. These

lessons in most cases include a certain process which has just been taught and one or more review processes. An example of this would be twelve or thirteen problems involving Case 2 in Percentage and three or four involving Discount. The first eight problems usually require easy one-step operations; and the last eight are more difficult, to tax the ability of the better students. These problems may be taken from textbooks or prepared by the teacher. When, several years ago, our school began its project in verbal problems our textbook was inadequate and so many of the lessons had to be prepared by the school. Many modern textbooks have abundant material in verbal problems, and so the problems may be taken from the book and not necessarily from one page. A fundamental point to remember is that these problems should be worded to necessitate careful reading and thinking. No lesson should contain one process so that putting down numbers and choosing a process as a matter of routine will allow the pupil to solve the problem without careful thinking.

The technique of giving these lessons is divided into four parts:

I. Preparation
II. Launching or Presentation
III. The Lesson, and
IV. Follow-up

In preparing for the lesson the teacher should anticipate any difficulties in computation and reading. Time is an important factor as the lesson should care for individual differences in ability, and involve remedial and follow-up work. The period if possible, should immediately precede an enrichment period. This enrichment period might be gymnasium, library, movies in correlation with another teacher, art or recreational reading. The materials needed are (1) a score card with answers for the sixteen problems, (2) two colors of marking pencils or crayons, (3) two sheets of paper for each child. Notebook paper is the most convenient size. Assign to each pupil a permanent serial number to correspond with his place on the official class roll.

In launching or presenting the lesson do the preliminary teaching in anticipation of difficulties. Then pass two sheets of paper to each child. Give specific directions about the lesson including the preparation of the paper (division into eight spaces by drawing a center horizontal line and three vertical lines); usual headings; using pencil to solve problems; showing ALL work on the paper, even if it can be done mentally. Now pass the sixteen problems and tell the pupils to go to work as soon as they receive them.

At the beginning of the lesson, that is when the pupils begin to solve the problems, note the time. The main lesson is to be twenty minutes of actual problem solving. This time may be extended to

twenty-five minutes if no one has completed correctly the sixteen problems at the end of twenty minutes. As the pupils work the teacher moves from desk to desk and puts a check with a colored pencil on each solution that is correct. When a child fails to solve the problem correctly, the teacher tells him it is incorrect and to try again before going on to new problems. If the second attempt is a failure, the teacher tries to discover the trouble and give whatever instruction she thinks is necessary for the pupil to solve the problem. When a pupil has completed all sixteen problems correctly, the teacher writes an eight across each of the sheets. Such pupils become teacher-assistants to help score other papers, using their own papers as a score card and the same color marking pencil as used by the teacher.

At the end of twenty (or twenty-five) minutes ALL work stops. The teacher completes the scoring and writes on the face of each sheet the number of problems correctly solved—8 if all are correct. The total of these two numbers is the pupil's score to be entered on the official record sheet. The pupils who have completed twelve or more problems go to the enrichment work. (This number may be changed by the teacher if in her judgment the lesson seemed particularly difficult.) The remaining pupils continue to work under the teacher's direction and assistance. If the other marking crayon is used a recount is unnecessary at time of copying the scores. These children may go to the enrichment activity at the discretion of the teacher, but never if the pupil does not have AT LEAST eight problems correct. Usually they should not go until they have twelve correct solutions. Each pupil's OFFICIAL score is the number of problems correct at the end of the twenty or twenty-five minute period.

The follow-up work consists of a period of remedial work and individual instruction for the pupils who do not go to the enrichment period. Keep a record of the official scores on your class roll and in some cases it is desirable to keep the unofficial scores. In our school we are asked to record at least five of the scores on the official class roll in the office, and a total of the scores for the semester. Frequent conferences with the principal about the work are desirable and helpful.

The most important day I remember in all my life is the one on which my teacher . . . came to me. I am filled with wonder when I consider the immeasurable contrast between the two lives which it connects.

—HELEN KELLER

IS BIOLOGY A SCIENCE COURSE?

Paul Klinge
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When the Prosser Resolution repeated the familiar fact that most high school graduates will not receive any further formal instruction after their graduation the implications for the science section of the secondary school curriculum was obvious. This has led some "experts" to confidently parrot the 1945 oracles of doom who gave impressive dicta about the atomic age and the necessity of a universal appreciation of science, and then signed up everyone in all the science courses available. Much of this "expert" opinion, however, is only a solemn contemplation of the navel. It disregards the content of the science courses the usual secondary school student will be exposed to before graduation.

The biology course is probably the only science course in which most high school graduates have ever been enrolled. It is not only the terminal science class for many; it is their only science exposure. But even if biology were not in this critical position, its importance in this century of scientific achievement would be solidly based on the fact that it deals with life itself, the most precious activity and yet the most inexplicable about which man is aware. It seems to be a custom for most scientists to deprecate the difficulty of their own particular field and to be awestruck at the complexities of another's. Harvard's Dr. Conant has recounted the chemist's admiration for the physicist, and the physicist's amazement at the intricacies of the field of the biologists. He goes on to say that the biologist admires the psychologist, and he in chain fashion expresses his awe for mathematics. There is good reason for the exalted physicist to recognize the biological field as difficult as the variables are many and the great unsolved problems of science lie in its field and associated subjects. The problem of life itself, photosynthesis, as well as the myriad questions raised in sociology, anthropology, and psychology concern the biologist.

Since the field is so broad, full of facts, and difficult, the biology course offers a convenient place to ride a hobby horse in glorious isolation from criticism. Each of the emphases in biology does not need a lawyer to prepare a brief of defense. Some biology courses are courses in nature study; some are scented from beginning to end with the cook book flavor in the form of workbooks, lab manuals, and standard recipes called "experiments." Some teachers inject the encompassing notion of conservation throughout the entire curriculum. Other schools find the science library emphasized, while many others watch the instructor twist to fit the wide field into the mold of human biol-

ogy. These trends which appear, disappear, and reappear, sometimes take the form of a "principles" course, with generalizations carefully listed at the end of each unit. Many instructors retain the old-fashioned college approach, so they keep the same content as their training courses, and use the same lecture method. And what is worse, now the trend seems to be to insist on biology teachers who have graduate training in a biological field, so that we have the spectacle of technical specialists in narrow, esoteric fields, teaching a general biology course. More than any other science course in the secondary school curriculum, the biology course, regardless of the syllabus on file in the principal's office, varies tremendously from school to school, and is the depository of varying emphases, even among its teachers within one school.

Yet biology is considered a science course, and as such must be able to be defended from that point of view. Have secondary school students whose sole exposure to science has been the biology course really been exposed to a science? Can the biology teacher defend his course as a course in the biological sciences or about biological facts? A visit to many biology classes would probably give convincing evidence that the methodology of science rarely enters into its teaching.

The classic definitions of science are no longer adequate to explain the work of modern science and its achievements. Even the brief and common conception of science as verified, classified facts never goes beyond the first day in many biology classes. Yet this 19th century definition is outmoded. Poincaire's observation that science is not a mere accumulation of facts any more than a pile of stones is a house has led the conceptions of science to emphasize the method by which the truth is pursued and the pattern which is used to correlate the facts. President Truman in his opening message to the 1948 American Association for the Advancement of Science meeting in Washington echoed the layman's understanding of science as primarily a method when he referred to it as "honest and uncompromising common sense." He further stated:

> "Science means a method of thought. That method is characterized by openmindedness, honesty, perserverance, and, above all, by an unflinching passion for knowledge and truth. When more of the peoples of the world have learned the ways of thought of the scientist, we shall have better reason to expect lasting peace and a fuller life for all."[1]

Top government scientist, Dr. E. U. Condon, gave a comprehensive definition of science as, "the process of study and the results of study of the facts of experience derived from a conscious program of observing, while systematically varying the factors of a given situation

[1] *Science*, September 24, 1948, Vol. 108, page 314.

in order to arrive at a rational understanding of the observational data so obtained."[2]

Even Condon's definition retains much of the classical flavor, and is difficult to apply to the biological sciences. A McGill University scientist, Dr. D. Ewen Cameron, pointed out that the conception of science as applied to the difficult biological subjects has undergone a significant shift.[3] The phenomenon of feedback mechanisms, or self-perpetuating reactions, can only be explained by new ideas of causality as essentially an elaborate pattern of events changing in time, rather than the simple straight line, lock step succession of events. There is no longer a need for absolutes, unchanging truths, final facts, for the biologists are working in open systems of plastic, conditional, working hypotheses. Because of the many variables in a biological experiment, and because a living mechanism changes constantly, the experimental approach in the biological sciences must be modified from the strict chemistry or physics type of experiment. Indeed science is really a form of behavior.

How can the high school biology course teach these new concepts of science as a method rather than a monolith of immutable principles? How can biology be made a science course at the tenth grade level? The time is certainly overdue for the overthrow of the archaic, traditionalist requirements of the colleges as they pertain to the secondary schools. The biology class is mainly made up of students who will never see a college classroom. Why teach sterile college entrance requirements to them? One medical school dean even expressed his wish that none of his pre-med students take any high school science, so that his teachers could teach what they pleased. Some of the colleges disdain the strictly college entrance type of high school biology course. But the high number who fail science courses in college is, of course, attributed by the colleges to low intelligence, laziness, or poor high school background, rather than poor college teaching or unreasonable course content.

But whatever type of student may be in the biology class some of the following techniques may help put across biology as a science course. These are not new or original but they need restatement, and they have been used in 10th grade classes. To teach the pupil that science strives for the truth regardless of its direction, a teacher might give extra credit or points if the teacher or a pupil giving a report can be found to be wrong on statement of biological fact. Pupils will soon find that authorities disagree, and some will read widely to catch the teacher. When there is disagreement, experiments can sometimes be set up to really find the truth. This encourages openmindedness and a

[2] *Science*, June 25, 1948, Vol. 107, page 659.
[3] *Science*, May 28, 1948, Vol. 107, pages 553–558.

passion for the truth; it reveals differences in texts; it teaches the relativity of the statements of the truth; and it promotes critical analysis so sorely needed today.

It has been found profitable to recount a famous biological experiment, and then pause to ask the class at the proper juncture for their ideas as to possible hypotheses to explain the facts brought out in the experiment, and possible methods to check the accuracy of their hypotheses. This can be done for almost any unit of work. Such accounts can be found in science magazines, radio talks on science, and articles by experienced science writers in popular magazines. This stimulates the imagination which is so frequently skipped in an explanation of the scientific method; Fleming in the discovery of the therapeutic values of penicillin had just the imagination the other observers lacked.

Still another technique is to formulate questions and its outline of the new unit to be presented by provoking the class to offer their previous knowledge and conceptions and vague ideas of the subject. To ask questions requires knowledge, but it also makes the student profoundly aware of the border between what is known and what is unknown. The closed mind which the orthodox science course sometimes produces never has the curiosity to look over the fence at what he might not know. These are the people to whom a little knowledge is a dangerous thing.

Having the pupils look through a stack of science magazines to find articles relevant to the subject at hand, as for example, heredity, not only acquaints them with the literature of science and how it is written, but they learn many new ideas in their reading. But what is most important, it teaches them to recognize the applications of their subject, or new advances in the field. The teacher who tries this will probably be surprised to find after he has carefully taught a unit how many students cannot pick out articles pertaining to the subject, particularly if the title is not the same as the title of the unit. Such a procedure also makes fun out of the essential study process of being able to abstract what is read.

The complicated fabric which is the cause and effect pattern in biology can be easily shown by conservation stories, practical applications of biological knowledge or principles, or hypothetical biological situations and possible outcomes. Another method to teach organization of data, and the incidental fact that many can organize differently but just as effectually, is to place before the student a long list of terms pertaining to the new unit, and then ask him to convert those terms into an outline, not bothering to write out the definition for any of the terms. This is a task which requires much work, but it does teach outlining, as well as the relatedness of facts.

When performing experiments, either demonstration or individual, it is sometimes valuable to suddenly stop the proceedings and ask for conjectures as to the next steps, possible hypotheses, possible verification methods. Then let the class argue out the disadvantages of each step or its advantages. Show how many conclusions can be made from the same set of data, and the ideas it suggests. This is sometimes effective in teaching the fact that some diametrically different conclusions have validity in different situations. It teaches the student to withhold final answers. It encourages the science pupil to see that questions are more important, or, at least, just as important as conclusions in modern science.

Individual semester projects, actually using the scientific procedure on a definite problem, are invaluable in training the better students in an application of the scientific attitude to a specific situation. This should not be required for all as many 10th grade students do not have the vigor, interest, or background to carry a project through to completion. Projects easily degenerate into a cookbook exercise, or a written report indicating a literary *Walpurgisnacht*. Many science projects have little or no scientific method in their development, nor display any thing more than artistic proclivities. But a real project, born as a problem in the student's mind, developed scientifically, will be completed as a contribution to his entire education.

To make the high school biology course valuable and interesting to the layman, it must lose its encyclopediac flavor, and must emphasize its connection with that critical attitude of the scientists that is the basis of a thinking electorate. Einstein points up the need succinctly when he writes:

> "It is of great importance that the general public be given an opportunity to experience—consciously and intelligently—the efforts and results of scientific research. It is not sufficient that each result be taken up, elaborated, and applied by a few hundred specialists in the field. Restricting the body of knowledge to a small group deadens the philosophical spirit of a people and leads to spiritual poverty."[4]

Biology deserves to return to the fold of the sciences. Its importance is indisputable, but to stay with the sciences it must be taught as such, and to be taught as a science, its teacher must retain that unswerving love of the truth which shall be communicated to his students as curiosity, rather than the willing acceptance of Olympian pronouncements on the authority of that terrible trinity—text, teacher, and tests.

[4] *The Educational Forum*, May, 1949, Vol. XIII, page 486.

ON THE CONTRIBUTIONS OF MATHEMATICS TO THE DEVELOPMENT OF ATOMIC ENERGY*

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INTRODUCTION

It is a privilege for me as a physicist to have this opportunity to give a tribute to the mathematicians without whose patient, penetrating, and brilliant work the spectacular recent advances of physics would not have been possible. It is easy for the layman to give undue credit to the physicists who too frequently have been paraded in the headlines in connection with the discovery and exploitation of atomic energy and to forget that their work stands upon a superstructure which mathematicians have had no small part in building. And yet it is well for us all to realize that we are using our God-given talents to penetrate into the mysteries of the amazing reality which He has created.

I would not presume to claim that this address is of an inclusive nature; the contributions of mathematics to the development of atomic energy are so numerous that I can only take samples from various branches of mathematics and show how they have been used to unleash the power of the atom. As an experimentalist I am not in as good a position as the theorist to be aware of many detailed contributions. Please understand, then, if I do not mention the contributions of the particular branch of mathematics in which some of you may be interested. The field of physics is so closely linked with all of mathematics that in this address I am certain to omit many important contributions which mathematicians have made.

A number of you are teaching in high school where you do not so so frequently come in contact with higher mathematics. All of us realize, of course, to what extent higher mathematics rests upon the more elementary branches, but I am sure it will interest you to see how much even the more elementary concepts are indispensable tools in the hands of the physicist. The contributions of higher mathematics are those of which we usually think, and it is easy to overlook the more obvious dependence of advances in physics upon elementary mathematical concepts.

There is always a great interplay of ideas between physics and pure mathematics. If we draw one circle to represent the domain of pure mathematics and another that of physics we can visualize a constant flow of ideas from the domain of pure mathematics into that of phys-

* Presented at the Mathematics Section of the Central Association of Science and Mathematics Teachers, November 25, 1949.

ics. But there is not a flow in one direction only. A certain problem often arises within the domain of physics which any of the ideas from the domain of pure mathematics seem inadequate to solve. The problem will then stimulate developments in certain areas of pure mathematics to meet the situation. Ideas then come out which are fed back into the area in physics which stimulated their development. One classical example of this is the invention of the differential calculus by Sir Isaac Newton who needed it as a tool to solve certain physical problems.

Historical Summary

It will be well to give a brief review of the historical developments associated with the discovery of atomic energy. We will then be in a better position to see how the various branches of mathematics have fed ideas, concepts, and methods into the various discoveries and thus form an indispensable part of them.

The story really began with the discovery of radioactivity by Becquerel in 1896. This discovery led to the research of the Curies who discovered and isolated radium and polonium between 1898 and 1901. Not long afterwards—in 1903—Rutherford and Soddy wrote a paper on radioactive transformations in which they formulated the radioactive decay laws in mathematical form. In 1905 Einstein advanced the special theory of relativity, one consequence of which is the now well-established equivalence between mass and energy expressed by the famous equation that the energy equivalence of a certain mass is equal to the product of that mass and the square of the velocity of light. In the period from 1908 to 1912 we have the invention and use of two of the most important tools for nuclear research—the Geiger counter and the Wilson Cloud chamber. During this same period (1911) Rutherford advanced the nuclear model of the atom and verified it by observing the large angle scattering of alpha particles. On the basis of picturing the atom as composed of a small central core containing the positive charge and nearly all of the mass surrounded by satellite electrons he developed the famous Rutherford scattering formula and verified it experimentally, arriving at the figure 10^{-12} cm. as the order of magnitude of the radius of the nucleus of the atom, whereas we know that atomic dimensions are of the order of 10^{-8} cm. In 1919 the brilliant Lord Rutherford made another important discovery; he succeeded in disintegrating atoms of nitrogen by bombardment with alpha particles. Then in 1924 Pauli showed that hyperfine spectra lines could be explained by nuclear magnetic movements and thus gave another important clue to the nature of the nucleus. In 1928 we have the application of wave mechanics to the interpretation of alpha particle emission by

Gamow and independently by Condon and Gurney—this gave the first clue that the methods of wave and quantum mechanics could be applied to the study of the nucleus. Important experimental contributions during the period between 1925 and 1930 were the development of linear amplifiers and scaling circuits which have been such powerful tools in connection with ionization chambers, proportional counters, and Geiger counters in the study of nuclear radiations. Another very important contribution was the development of a precision mass spectrograph by Aston which made it possible to obtain the mass of isotopes with high precision.

Various research programs starting in about 1930 were to bring in a new era in the field of nuclear physics. One of the most important of these researches from the standpoint of the development of atomic energy was the discovery of a new elementary particle—the neutron—by Sir James Chadwick between 1930 and 1932. Parallelling this work was the development of the cyclotron by Lawrence and Livingstone between 1930 and 1934 and of the Van de Graaff generator by Van de Graaff in 1931. The development of machines to accelerate atomic particles led to the first artificial nuclear disintegration with particles artificially produced—the splitting of Li into two alpha particles when bombarded with protons. Then in 1933 artificial radioactivity was discovered by Curie Joliot.

The research work leading quite directly to the development of the Chain-reacting pile and later to the atomic bomb were begun by Enrico Fermi in 1934 when he discovered the slow neutron and put it to work bombarding many kinds of atoms in the periodic table. Fermi discovered that by surrounding a source of fast, high energy neutrons (a mixture of radium and beryllium) with materials containing much hydrogen such as paraffin and water that the neutrons were slowed down by elastic collisions to energies comparable to the energies of atoms and molecules resulting from their thermal agitation. This as we shall see has been of tremendous importance, since these so-called thermal neutrons are much more readily captured by atomic nuclei than are fast neutrons. By bombarding many atomic nuclei with thermal neutrons many new radioactive isotopes were produced.

Quite naturally Fermi wondered what would happen if uranium atoms were bombarded with neutrons. Since a frequent process in neutron capture is for the atomic weight to increase approximately by one unit and for the nuclear charge to increase by the emission of one or more beta rays he expected that atoms heavier and having a greater nuclear charge than U238 would be produced, that is, transmanic elements. In doing this experiment some strange things resulted; instead of only one radioactive substance with a characteristic

half life there were at least four. It remained for Hahn and Strassman in 1939 to discover that one of the radioactive substances was barium —an element much lighter than uranium. Lise Meitner guessed the answer—that atoms of uranium were being split into two particles of comparable mass—the process we now call nuclear fission. In the next year (1940) Szilard and Zinn discovered that neutrons were emitted in the fission process and Dunning showed that it was the isotope U235 which underwent fission by thermal neutrons. In 1941 Wahl, Segre, and others isolated plutonium element 94 and showed that it (the isotope of mass number 239) underwent fission by thermal neutrons.

The war situation rapidly speeded up research in nuclear physics because the experts soon realized that since neutrons were emitted in fission it might be possible to produce a divergent chain reaction leading to the release of atomic (nuclear) energy in explosive proportions. The Manhattan District was organized in this country, and under the direction of Enrico Fermi the first divergent chain reaction was produced at the University of Chicago in December of 1942. The reality of atomic energy released in sufficient proportions that one could warm his hands by touching the atomic pile further spurred research until a very large percentage of the scientists in the country were involved in it, and the result has had world shaking consequences: on July 16, 1945 the first explosive release of atomic energy was realized. Since that time the field has been very active in the pursuit of ways to utilize the power of the atom.

Examples of Contributions from Various Branches of Mathematics

It is impossible to separate any of the quantitative results in physics from their formulation in mathematical form. Since mathematics has been so universally used in connection with the discoveries outlined above I shall only select certain representative examples from various branches of mathematics. Let us look at contributions from some of these branches.

A. *Elementary Algebra, Geometry, Trigonometry, and Analytic Geometry*

We all recognize that the elementary branches of mathematics are foundational to the higher branches, but it is interesting to see how some of these elementary branches have contributed directly to important discoveries. Take, for example, the nuclear model of the atom and the Rutherford Scattering formula. On the basis of classical mechanics and of assuming a repulsive force between the alpha particle and scattering nucleus proportional to $1/r^2$, where r is

the separation between the particles, Rutherford[1] showed that the path of an alpha particle scattered by a heavy nucleus was that of an hyperbola. The generalization of this result by Darwin[2] indicated that in the center of mass system the scattering of an alpha particle by a light nucleus, having a mass comparable to that of the alpha particle, can be represented by a combination of hyperbolas having the same asymptotes but different eccentricities—the scattered particle traveling on one hyperbola and the recoil nucleus on the other.

It also turns out that the application of the conservation of mass-energy and momentum in nuclear reactions yields algebraic equations of the second degree.

Consider the reaction:

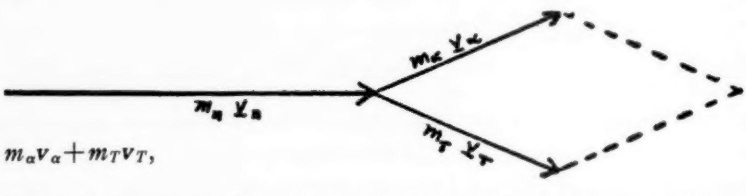
$${}_0n^1 + {}_3\mathrm{Li}^6 \rightarrow {}_1\mathrm{H}^3 + {}_2\mathrm{He}^4 + Q \qquad Q = 4.6\ 8\ \mathrm{Mev}.$$

From the conservation of mass-energy,

$$E_n + Q = E_\alpha - E_T, \quad \text{or} \quad \tfrac{1}{2}m_n v_n^2 + Q = \tfrac{1}{2}mv^2 - \tfrac{1}{2}m_T v_T^2,$$

where E_n, n_n, and v_n are respectively the energy, mass, and speed of the incident neutron, and the quantities with subscripts α and T are the corresponding quantities for the α-particle and the triton.

From the conservation of linear momentum we have the vector equation



$$m_n \mathbf{v}_n = m_\alpha \mathbf{v}_\alpha + m_T \mathbf{v}_T,$$

where the $\mathbf{v}$'s represent the vector velocities of the various particles.

From the application of algebra and trigonometry alone it can then be shown that the relationship between the energy of any two particles, say E_n and E_T is an equation of the second degree. Applying analytic geometry to this result it can then be shown that conic sections—hyperbolas or parabolas are obtained. It appears that the above reaction will prove of importance in measuring the energy of fast neutrons.

A similar analysis is applied to determine the energy of neutrons emitted by various reaction in, say, the Van de Graaff generator. For example, in the reaction

$${}_1\mathrm{H}^1 + {}_3\mathrm{Li}^7 \rightarrow {}_0\mathrm{n}^1 + {}_4\mathrm{Be}^7 + Q,$$

a similar analysis is used to determine the energy of neutrons given off at various angles from the Van de Graaff lithium target.

The study of reactions induced by monoenergetic neutrons produced in the Van de Graaff generator has contributed much indispensable data for work in atomic energy. The same procedure is applied to determine the energy of neutrons elastically scattered in particular directions by moderating materials.

B. Differential and Integral Calculus

I daresay there is not a single contribution leading to the release of atomic energy that has not in some way involved the use of the calculus either directly or indirectly. This powerful method of working with quantities that vary in space and with time is universally used in nuclear physics. One example is the equation of Bethe[3] for the rate of energy loss of heavy charged particles passing through matter derived from quantum mechanics. The equation for non-relativistic energies is

$$\frac{dE}{dX} = -\frac{4\pi e^4 Z^2 Z' N}{mV^2} \log_e \frac{2mV^2}{I}$$

where e is the charge on the electron, Z is the atomic number of the charged particle, Z' is the atomic number of the element through which the particle is passing, N is the number of atoms per cubic centimeter, m is the electron mass, and I is an average ionization potential for removing electrons from the atoms of the stopping material. This equation can be used as it stands to study the ionization per unit path, but it must be integrated if it is to be used to predict the range of the part cles in the element. The integration involves the use of certain exponential integrals. This equation has been of great use in the study of range-energy relationships for charged particles. These range energy relationships have been of the utmost importance in the measurement of the energy of fast neutrons. Measurements of the range of protons, knocked through the gas in a counter of cloud chamber, or through a photographic emulsion determine the energy of the neutrons that hit them.

C. First Order Differential Equations

Differential equations have been indispensable in the study of dynamical processes in all branches of physics. The example which I have chosen to illustrate the use of a first order linear differential equation is the Rutherford-Soddy theory of radioactive transformations advanced in 1903 and its generalization by Batemen[4] in 1910. This work has truly been one of the great foundations in nuclear physics, and any scientist who has worked on the Manhattan Project or for the Atomic Energy Commission can testify to its constant use.

The simplest equation is for a single radioactive species. If N is the number of atoms of the substance at time t and λ is the fraction which decay per unit time the equation is

$$\frac{dN}{dt} = -\lambda N$$

and its solution is

$$N = N_0 e^{-\lambda t}$$

where N_0 is the number of atoms at an arbitrary zero time. If the parent radioactive substance decays into a radioactive daughter substance, the equation giving the rate of change in the number of daughter atoms is

$$\frac{dN_2}{dt} = N_1\lambda_1 - N_2\lambda_2.$$

(The subscripts 1 and 2 refer to parent and daughter substances respectively.)

The solution of this equation is

$$N_2 = \frac{\lambda_i}{\lambda_2 - \lambda_1} N_1{}^0 e^{-\lambda_1 t} + \left(N_2{}^0 - \frac{\lambda_1 N_1{}^0}{\lambda_2 - \lambda_1}\right) e^{-\lambda_2 t},$$

where the superscripts refer to the number of atoms of parent and daughter substances at zero time. Bateman generalized this result for the ith generation:

$$\frac{dN_i}{dt} = N_{i-1}\lambda_{i-1} - N_i\lambda_i$$

and the solution is

$$N_i = a_i e^{-\lambda_1 t} + b_i e^{-\lambda_2 t} + c_i e^{-\lambda_3 t} + \cdots + I_i e^{-\lambda_i t},$$

where the coefficients a_i, b_i, C_i, $\cdots$, I_i are functions of the disintegration constants λ_j and of the number of parent atoms at zero time (it is assumed that one starts with the pure parent). The coefficients can be expressed in terms of recursion formulas.

D. *Second Order Differential Equations*

Perhaps no single branch of higher mathematics has been used so extensively in nuclear physics as that involving the use and solutions of partial differential equations of the second order. I need only remind you that the Schrodinger wave equation which has been foundational in wave mechanics is an equation of this type. Quantum

mechanical methods are used extensively in the study of nuclear reactions. A more direct contribution to the development of nuclear reactors is the use of the diffusion equation for slow neutrons.

Suppose we have a homogeneous medium, such as graphite, containing neutrons in thermal equilibrium with the carbon atoms. The neutrons will be bouncing around with a speed of about 2200 meters per second, undergoing elastic scattering by the carbon atoms gaining, on the average, as much energy as they loose. If v is the velocity of the neutrons and λ their mean free path between collisions, we have the diffusion coefficient $D=\lambda v/3$. If n is the number of neutrons per cubic centimeter in the graphite at time t, we have as the diffusion equation[5]

$$\text{div } (D \text{ grad } n)+\text{production/cc. sec.}-\text{absorption/cc. sec.}=\frac{\partial n}{\partial t}\cdot$$

If q is the rate of production/cc. of thermal neutrons, and if Λ is the mean free path for absorption this equation can be written as

$$D\nabla^2 n+q-\frac{v}{\Lambda}\,n=\frac{\partial n}{\partial t},$$

where ∇^2 is the operator

$$\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial Z^2}\cdot$$

If we consider the steady state condition (i.e. $\partial n/\partial t=0$) we have the time independent equation

$$D\nabla^2 n+q-\frac{v}{\Lambda}\,n=0,$$

for which we can obtain various solutions, depending upon the nature of the source q and upon the boundary conditions. The solution for a plane source in an infinite medium is

$$n=\frac{3LQ}{2\lambda v}\,e^{-|Z|/L},$$

where $L^2\equiv\lambda\Lambda/3$, and Q is the source strength in neutrons/cm^2 in the plane $Z=0$. For this special case the neutron density falls off exponentially with the distance from the plane source. This equation, together with the Fermi "Age equation" which concerns the slowing down of neutrons by elastic collisions, have been indispensable in the development of the theory of the chain reacting pile, consisting, for example, of uranium lumps imbedded in a large mass of graphite.

The fast neutrons given off in the fission of U235 are slowed down through elastic collisions with the carbon atoms and those surviving capture come into thermal equilibrium with the graphite. They then diffuse around until captured or until they escape from the boundaries of the pile.

E. Mathematical Statistics

Our illustrations would certainly be incomplete if we did not at least mention the contribution of mathematical statistics. The diffusion of neutrons is in essence a statistical process, just as is radioactive decay. One especially recognizes the truth of the latter when he realizes that Poisson's equation is used when one works with a small number of disintegration processes. Poisson's equation is

$$W(m)=\frac{M^m e^{-M}}{m!},$$

where $W(m)$ is the probability of observing m events per unit time when M is the average number of events per unit time obtained by observations over many time intervals. This equation is used directly to determine the dead or insensitive time of a counting circuit, i.e. the time interval following the passage of a pulse through the circuit during which the circuit will not accept a second pulse. This has been useful in obtaining accurate data in connection with experiments on nuclear reactors.

It is well to remind ourselves also that the theory of heavy nuclei is a statistical theory, since there are many particles—neutrons and protons in heavy nuclei, such as that of uranium 235.

F. Other Branches

I doubt if there is a single branch of mathematics that has not made either direct or indirect contributions in the development of atomic energy. We can mention, for example, the extensive use of Fourier series and complex variable in the design of amplifiers, an indispensable part of counting equipment for the study of nuclear reactions. We can mention the use of matrix algebra in the solution of nuclear problems by quantum mechanical methods. The systems in algebra, etc., which are being used in connection with the development of electronic computing machines (such as binary systems) by J. Von Neumann and others is also of great importance since these machines are being used to solve problems relating to the development of atomic energy.

Conclusion

I trust that as we have reviewed together a few of the ideas that have been fed into physics by mathematics and the constant use of mathematical methods in physics you have been helped to realize that the development of atomic energy rests heavily upon mathematics—is it any wonder that mathematics is often described as the "queen of the sciences"? I trust that you will realize that as you train students to think in mathematical terms and that as you do research in mathematics that you are making a real contribution to technological development as a whole.

Yet these advances can destroy human lives, and science itself does not have the answer to man's most pressing problems. I believe that we must look to God for wisdom in order to use our knowledge wisely—otherwise the consequences may be disastrous to ourselves and to those whom we love.

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4. Bateman, *Proc. Camb. Phil. Soc.*, *15*, 423, 1910.
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NEW MOTION PICTURES

Four new educational motion pictures are being released by Encyclopaedia Britannica Films, it was announced by C. Scott Fletcher, president of the educational film producing company. The new films are:

THE EARS AND HEARING, a one-reel 16 mm. black and white subject, describes the physiology and functions of the human ear with animated drawings and close-up photography and explains common causes of impaired hearing.

LIFE OF A PLANT, a one-reel color subject created primarily for middle grade science classes, shows steps in the life cycle of a typical flowering plant, the pea, by means of time-lapse photography and animated drawing.

COPPER: MINING AND SMELTING, in full color, is one of a continuing series of EB Films on the natural resources and technological processes in use in the United States. The film gives a graphic account of an open pit copper mine in operation and illustrates the main steps in extracting copper from ore.

YOURS IS THE LAND is a 20-minute forum film, in color, designed primarily for use in discussion groups and meetings interested in the national problems of land, forest and water conservation.

More detailed descriptions of the four new films are attached.

Train up a child in the way he should go . . . and walk there yourself once in a while.

—Josh Billings

MERCATOR PROJECTION

ITS BASIS IN ELEMENTARY MATHEMATICS

CLARENCE L. VINGE
Michigan State College, East Lansing, Michigan

Teachers of geography and cartography courses often either omit all explanation of projection construction, or give only that which can be made in terms of descriptive geometry. This practise is understandable for projections which are little used or of extreme mathematical complexity. It is unfortunate however that the venerable and useful Mercator projection (Fig. 1) also receives this treatment. Even worse, the literature is singularly devoid of a source to which the student can turn for a simplified explanation of the basic mathematics of the Mercator.[1]

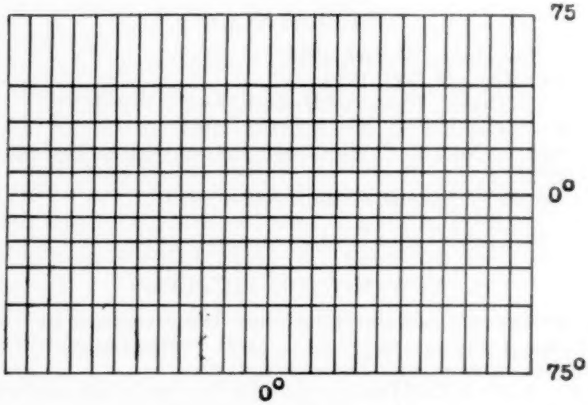

FIG. 1. Mercator grid. If the earth were as symbolized by the Mercator grid, every degree of longitude would have the same length and each degree of latitude would become progressively wider from the equator toward the poles.

There is general agreement that the two most valuable properties of the Mercator are (1) a straightedge line is a line of constant direction, and (2) conformality.

Definition and explanation of the first property depends on (a) meaning of the term *direction* in navigation, and (b) a theorem from elementary geometry—if parallel lines are cut by a transversal, corresponding angles are equal. Directions north, south, east, and west, called the four cardinal directions, are used accurately even by youngsters. South is often visualized as being an imaginary line across

[1] For a general discussion of projections and their properties see "Map Projections for an Air Age," by Walter G. Gingery, this magazine, Vol. XLIV, No. 382, February 1944, pp. 101–111; for a list of formulas for grid construction, including Mercator, see "Simple Mapping Formulas," by C. E. Rhodes, this magazine, Vol. XLIII, No. 374, March 1943, pp. 221–224.

terrain toward noonday sun. North is taken as the opposite of south. At right angles to the north-south direction, east is taken toward rising sun and west toward setting sun. But the concept *direction* can be given a more useful meaning if it is associated primarily with the nature of the earth itself. The earth rotates on its axis, the ends of which are called North and South Poles. Fitted to the rotating earth is an imaginary grid of north-south lines called longitude lines converging on the poles; cutting longitude lines at right angles are east-west latitude lines. In navigation, direction of a course line is *the angle* between a longitude line and the course line. This angle is measured clockwise from a position north of point of departure (Fig. 2). Thus, in terms of angles, east is 90°; south, 180°; west, 270°; and north, 360° or 0°.

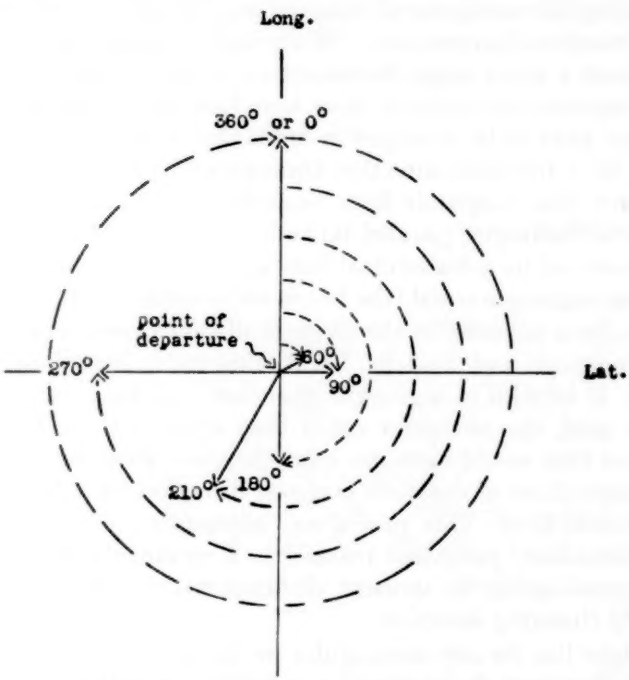

FIG. 2. Directions of navigator's straightedge lines shown by their angles as measured from true north, i.e., 0° or 360°.

On a globe, pull a string taut between Singapore and Seattle. This would be the shortest distance between the two places, and the path one would probably prefer. But now check direction angles from Singapore along the path toward Seattle. The angle is about 45° near Singapore, gradually changes to 75° mid-way, and near Seattle is approximately 100°. The path, then, does not have *one* direction,

but rather *many;* actually an infinite number of directions between 45° and 100°. Because of the physical impossibility of constantly changing direction, the navigator of a ship cannot exactly duplicate such a path.[2]

The only way he can guide his ship is by determination of the angle between true north (a longitude line) and his course line. This he finds by use of the compass needle, the ends of which point toward the magnetic polar areas which are fairly close to the true geographical poles (ends of axis of rotation where longitude lines converge). Because magnetic or compass directions can easily be changed to true directions, assume for the following that the magnetic polar areas and the geographical poles have the same location, i.e., direct compass readings would represent true directions.

In steering, the navigator (if he is not merely following visible landmarks—shoreline features, etc.) is virtually entirely dependent on making good a given angle between true north and his path. If the earth's longitude and latitude lines were laid out on flat paper, how would they have to be arranged in order that a navigator's straightedge line have the same direction throughout its length? This would only require that longitude lines be straight and parallel, and that they intersect straight, parallel latitude lines at right angles. If parallel lines are cut by a transversal (navigator's straightedge line), corresponding angles are equal (the line is one of constant direction).

Return for a moment to the shortest distance route examined between Singapore and Seattle. Break this route into a number of segments. If termini of segments (their lat. and long.) were plotted on above grid, the navigator could then connect them by straight lines—lines that would have the same direction all along their paths. Such straight lines of constant compass direction on a Mercator are called rhumb lines. This procedure, segmenting of a great circle (shortest distance) route and transfer to a rectangular grid, makes a close approximation to shortest distance without the necessity of constantly changing direction.

A straight line on any rectangular projection will have a constant direction. However, if spacing of parallel lines is without appropriate system the shapes of features drawn on such a grid are likely to be unrecognizable compared to their real counterparts. This leads to the second excellent property of the Mercator, namely, conformality.

Conformality means correct portrayal of shapes or outlines of small

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[2] In order for a navigator to determine the path which represents the shortest distance between two places, he need only connect the two places by a straight line on a *gnomonic* projection. The paths of all straight lines on a gnomonic represent arcs of *great circles;* a great circle on the earth is defined by the intersection of the earth's surface with a plane passing through the center of the earth. The path of an arc of a great circle passing through two places is the shortest distance between them.

features. Navigators making landfall find this property indispensable in their charts. The Mercator projection (Fig. 1), because of parallel, evenly-spaced longitude grid lines in contrast to convergence of longitude lines on the earth, "stretches" east-west distances more and more the nearer the poles. In order to preserve shape, the east-west expansion is matched by equal north-south expansion, i.e., by spacing latitude lines further and further apart the higher the latitude.

The mathematics of Mercator conformality is best preceded by discussion of certain properties of (a) circles, and (b) right triangles. The length of circumference of a circle equals length of its radius multiplied by 2π, that is $2\pi r=c$. Circumference always has a fixed length with respect to its radius; stated differently, circumference varies directly according to the length of its radius. A circle with radius one-half the length of radius of a larger circle will have a circumference of but half the length of circumference of larger circle. Apply these ideas to Figure 3. First compare the radius of the smallest circle

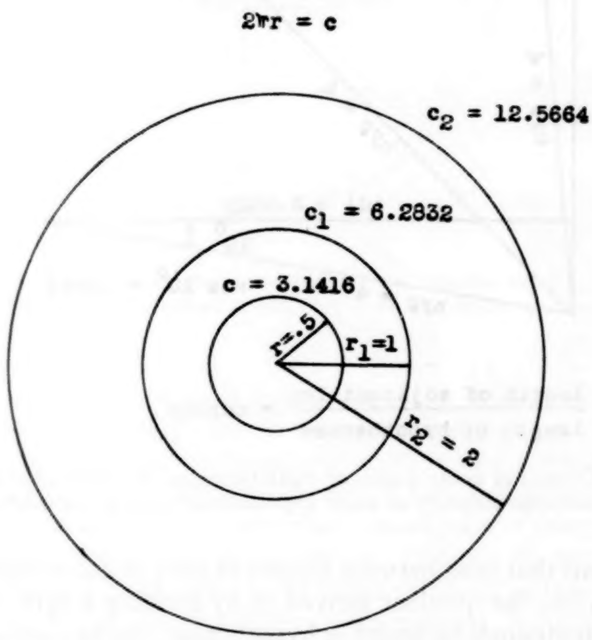


FIG. 3. Circumferences of circles vary in length in direct proportion to the lengths of their radii.

with that of the next larger: $r=.5$, $r_1=1$; $.5/1=\frac{1}{2}$. Now compare circumferences: $c=3.1416$, $c_1=6.2832$; $3.1416/6.2832=\frac{1}{2}$. If radius to radius proportion always equals circumference to circumference proportion then, if two radii and a circumference are known, the other

circumference can be calculated. For example, from Figure 3, determine length of c (circumference of smallest circle) knowing that $r=.5$, $r_2=2$, and $c_2=12.5664$. Without putting into equation form, the short radius ($r=.5$) is only one-fourth length of long radius ($r_2=2$), therefore small circumference is only one-fourth length of long circumference ($c_2=12.5664$) and $c=3.1416$. In equation form: $(r/r_2)\times c_2=c$.

Preliminary notions regarding right triangles (Fig. 4) are largely those of elementary trigonometry. Here concern is principally with

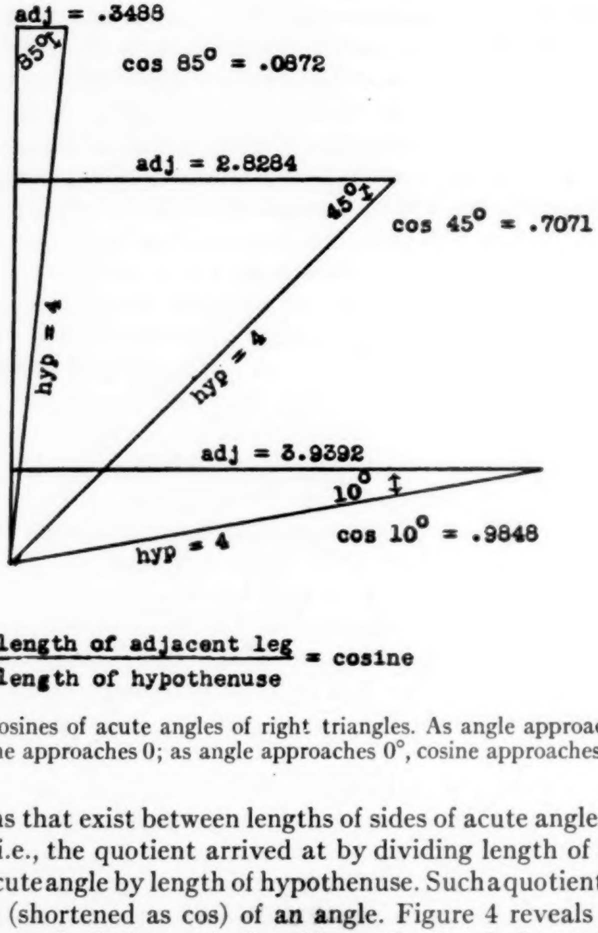


FIG. 4. Cosines of acute angles of right triangles. As angle approaches 90° cosine approaches 0; as angle approaches 0°, cosine approaches 1.

proportions that exist between lengths of sides of acute angles of right triangles, i.e., the quotient arrived at by dividing length of adjacent leg of an acute angle by length of hypothenuse. Such a quotient is called the cosine (shortened as cos) of an angle. Figure 4 reveals that the smaller the angle the longer is the adjacent leg in relation to hypothenuse—that as angle approaches 0°, quotient (cos) approaches 1; also that the larger the angle the shorter becomes adjacent leg in relation to hypothenuse—that as angle approaches 90° cos becomes very small, approaches zero. It should be noted that cos of 45° is not .5, as

one might assume from the fact that cos 0° is 1 and that cos 90° is 0, viz., value of cos does not vary directly in proportion to change in size of angle.

The preceding ideas with respect to circles and triangles can now be applied to the actual earth, or perhaps better imagine Figure 5 as a

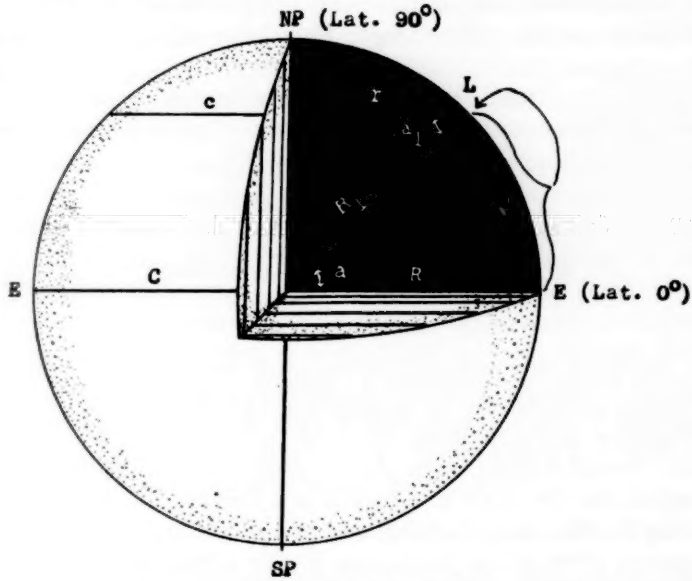


FIG. 5. Globe with *more than* one-eighth of its volume cut away. Note that r equals radius of circumference c, and that R equals radius of circumference C, i.e., equator.

globe whose equator is same length as that of equator on Mercator grid shown in Figure 1. The letters in Figure 5 mean as follows: capitals C and R refer to lengths of equatorial circumference and radius, respectively; R_1 equals R because it has same point of origin at center of globe and extends to surface; small c and r refer to circumference and radius of a circle of latitude. The two angles, shown by short arrows and small a and a_1 are equal—if two parallels are cut by a straight line, alternate-interior angles are equal. A position of latitude is given by capital L; L is equal to angle a.

From study of circles, there is at hand an easy method of finding the length of a circle of latitude if length of equator (lat. 0°) is known. Circumferences vary directly as their radii: $c/C=r/R$; multiplying both sides by C gives $c=(r/R)\times C$. Figure 5 shows $R_1=R$, therefore equation can be stated $(r/R_1)\times C=c$. Angle a equals latitude of circle whose circumference is desired. From Figure 5, $r/R_1=\cos a_1$. Since

angle a_1 equals angle a, then $r/R_1 = \cos a$. The cos of any angle can be found by using a table of cosines. Cos of a given latitude times equatorial circumference ($\cos a \times C$) equals length of circle of latitude (c). This divided by 360 equals length of 1° of longitude. Using table of selected cosines (Table 1) the reader can compute the progressively shorter lengths of degrees of longitude as they approach the pole. A degree of longitude on equator equals approximately 70 miles; equation to use is cos lat. $\times 70 =$ length 1° of long. at lat. for which cos is found.

TABLE 1. SELECTED COSINE VALUES

cos of 90° angle	= .0000
75°	= .2588
60°	= .5000
45°	= .7071
30°	= .8660
15°	= .9659
0°	= 1.0000

The equation, $\cos a \times (C/360) =$ length of 1° of *earth* long. at lat. a, describes convergence of longitude lines toward the poles. But on the Mercator grid longitude lines do not converge, but rather are parallel, evenly-spaced lines. Every degree of longitude, regardless of location, has the same *grid* length as a degree of longitude at equator: thus, $C/360 =$ length of any degree of *grid* longitude. If both sides of equation given at the beginning of this paragraph are divided by $\cos a$, the following is obtained:

$$\frac{\cancel{\cos}\, a \times \dfrac{C}{360}}{\cancel{\cos}\, a} = \frac{\text{length of } 1^\circ \text{ of earth long. at lat. } a}{\cos a}$$

If $C/360 =$ length of any degree of grid long., and also if

$$\frac{C}{360} = \frac{\text{length of } 1^\circ \text{ of earth long. at lat. } a}{\cos a},$$

then,

$$\text{length of any degree of grid long.} = \frac{\text{length of } 1^\circ \text{ of earth long. at lat. } a}{\cos a}.$$

Restating, if length of a degree of earth longitude is divided by cos of its latitude, quotient will be a number equal to magnitude of a degree of earth longitude at equator, and would be the same regardless of location being near equator or near poles, that is, longitude lines would be parallel and evenly-spaced.

East-west "stretch" of grid is determined by dividing length of a degree of earth longitude by cos of its latitude. Working poleward from equator, *proportional* north-south matching "stretch" of grid is obtained by dividing each successive narrow band of latitude by the cos of its mean latitude. Because each latitude angle has a different cos (an inverse, non-linear function),each band of latitude is expanded differently from its neighbor. Therefore the narrower the bands used the greater the accuracy,i e., the nearer the approach to conformality.

The reader can check the expanding latitude grid from the equator poleward by using Table 1; consider a degree of latitude as being equal to approximately 70 miles anywhere on the earth. Small cos values of high latitudes mean more "grid miles" per degree than actual. For example, grid distance near equator would be just greater than 70 miles; grid distance of a degree of latitude at 45° would be approximately 100 miles, (70/.7); at 75°, grid distance equals about 270, (70/.26).

Thus conformality is obtained by basing expansion—calculated grid distances[3]—on division of earth longitude and latitude distances by the cosines of their latitudes.[4] Fortunately methods of calculus can be applied that not only reduce labor of computation but also give more perfect results. The more advanced techniques include a correction factor for the spheroid nature of the earth.

[3] These *calculated grid distances* are plotted to scale in laying out the projection, for example, one-half inch on grid to 100 miles of *calculated* distance.

[4] Reciprocal of cos is secant, therefore multiplication by secant can be used instead of division by cos.

SUMMER SCHOOL IN HAWAII

New economies in Hawaiian vacations are possible through inexpensive accommodations arranged by Hawaii Hosts, according to Honolulu officials of United Air Lines.

Hawaii Hosts was organized in Honolulu last year to help stretch the budgets of students and teachers who come from the Mainland to attend summer school at the University of Hawaii. Accommodations in small hotels and private homes are provided for scholars at $1.50 per day and up.

This year, in addition to teachers and students, Hawaii Hosts is opening its services to anyone in the middle income group, say United officials. Tours of Honolulu and the vicinity are offered for as little as 20 cents. Low cost lodging on outlying islands also has been arranged.

As a further economy, 10 per cent discounts on round-trip flights between California and Hawaii continue in force on United's new fleet of Mainliner Stratocruisers. The giant, double-decked airliners were introduced on the San Francisco-Honolulu segment of the company's 10,700-mile system early this year.

A high-speed camera made pictures in one twenty-millionth of a second by the use of high voltage passed through the electrodes of a cell which in conjunction with polarized light acted as an electrical shutter.

STORAGE OF CLASSROOM VISUAL MATERIALS

Muriel Beuschlein
Parker Elementary School

AND

James M. Sanders
Chicago Teachers College

Storage space is a problem faced by most teachers. That no two objects can occupy the same space at the same time is proved daily on the cupboard shelf. However, optimistic teachers are constantly attempting to disprove this scientific law. There are limitations to what may be kept and used but orderly arrangement helps to extend the existing space.

How can teaching materials be organized and stored from one unit period to another with the maximum utilization of a minimum of time and space? With the impetus given to the collection and acquisition of free and inexpensive material from industries, foundations and museums by the publication of free lists of available free material[1] this problem becomes more acute and provoking to the alert teacher.

One of the first suggestions is to resist the temptation to send for large quantities of interesting titles in a haphazard manner until you have at least organized a system for conveniently handling such items. Selection of material for units according to the teaching order, followed by material anticipated for the next semester, gives the immediate needs first preference and temporarily eases the storage situation.

A class project recently tested in a 6B classroom[2] may be varied or developed to fit individual needs under other conditions or circumstances. Each of three groups of boys selected sturdy orange crates with covers. Apple boxes were first used and though strong and not requiring the insertion of a lining to keep out dust they proved to be $\frac{1}{2}$ inch too narrow for regular size manila folders and cutting these to size was time-consuming and troublesome so that it was simpler to adapt the orange containers. The problems of minor changes of position of wooden slats, extracting nails and hinging the covers onto the crates were solved by each group individually. The boxes were then sanded, painted, and lined with heavy wrapping paper. Filing folders containing the materials were then set in at right angles to the middle partition. This is the only way they will fit in and stand upright.

Organization of the material for the folders was carried out by other

[1] Beuschlein, M. and Sanders, James M. Free and Inexpensive Teaching Aids for the Science Teacher, *Chicago Schools Journal Supplement*, October 1949.

[2] Parker Elementary School.

pupil committees during the reconstruction and preparation of the crates. Cardboard dividers were cut, covered with colored paper, and lettered distinctly with handprinted labels. Pictures for bulletin boards were placed in large envelopes. These had been salvaged, from the best of those in which the free materials had been received, and then appropriately labelled. Small pictures, diagrams and short articles were mounted on plain notebook paper and inclosed in a folder or fastened within a cover. Pamphlets, leaflets, pictures and whatever was to be used were grouped according to separate units. These units were indexed on the crate in front of the compartment in which they were filed. Many pamphlets were cut apart and only useful pictures and pertinent textual material retained. This was to conserve space.

With this much of the project under way and some of the material in use, a very willing committee stapled colored construction paper covers onto pamphlets and leaflets so they would last longer and also be more attractive. Lettering, and in some cases decorating, of these was the following step. These covers will need replacing from time to time but the materials inside will be protected, preserved and kept clean.

Duplicates can also be made into this type of booklet and used for supplementary reading or placed on the room library shelf. A "library" committee made pockets to paste inside the paper covers, and cards for each title. Checking these booklets in and out gave many a child library experience which developed accuracy and responsibility. Attractive and interesting pamphlets stored in the teacher's file or pasted in a scrap book are of little instructional value but on the classroom library shelf they can and will be used profitably by many children.

Storage of large charts or maps can be simplified by selecting those needed right away and storing the others. All charts, relating to a unit and close to each other in content areas as well, should be rolled together and placed in one of the large mailing tubes in which originally received. This container should be descriptively labeled and the items enumerated or listed. If the charts currently needed are unrolled and fastened hanging free inside a closet door they will uncurl by their own weight and soon be hanging straight and ready for use on the classroom walls. This should be done a few days ahead of their appearance in the unit sequence.

Labelled cigar boxes are satisfactory for saving and storing demonstration materials such as insects, seed pods, and sample of grains, or fibers. Test tubes, watch glasses and small pieces of equipment may also be put in cigar boxes. These are easily stacked and can be placed on the top of a dressing room closet, if such space is available.

With a wealth of pictures no further away, nor no more expensive than a postal card, a bulletin board becomes a source of increased learning, not just something seasonal or decorative. Here again pupil help can be effectively utilized. Groups take pride in planning and executing a well balanced, informative display. The children become alert to other sources of additional materials which they may obtain and contribute, and they watch the board to see what the other groups will do.

Of course standard filing cabinets would be preferable, although few school systems make such equipment available to individual elementary school classrooms. The orange boxes are makeshifts but the vertical file system and the activities of the children are equally valuable no matter where the material is arranged or stored.

The project in its entirety requires considerable time and teacher organization and planning. The results are gratifying, particularly the satisfaction of having at your finger tips a growing reserve of visual material for each unit, as well as a cooperative room full of children with great interest and enthusiasm for *"Our File."*

PROBLEM DEPARTMENT

Conducted by G. H. Jamison
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you suppose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2175. *Wm. Johnson, Cleveland, Ohio; John Hinds and Homer Price, Los Angeles, Calif.; M. Dreiling, Collegeville, Ind.; E. C. Rodway, Ontario, Canada; David Allen, Clarence, N. Y.*

2176. *E. C. Rodway, Ontario, Canada.*

2177. *E. C. Rodway, Ontario, Canada.*

2178. *Wm. Johnson, Cleveland, Ohio; Jerome Glick, Brooklyn College; Glenn Sands, Anderson, Indiana; E. C. Rodway, Ontario, Canada.*

2179. *Proposed by Adrian Struyk, Paterson, N. J.*

If the square of the arithmetic mean of two numbers is equal to the sum of the squares of their geometric and harmonic means, then the two numbers and their arithmetic and harmonic means can be arranged in geometric progression.

Solution by W. R. Talbot, Jefferson City, Mo.

Let a and b be the numbers, A their arithmetic mean, G their geometric mean, and H their harmonic mean. Substituting $A=a+b/2$, $G^2=ab$, $H=2ab/a+b$ into $A^2=G^2+H^2$ gives $b^2+4ab-a^2=0$ so that $b=(\pm\sqrt{5}-2)a$. Then $A=(\pm\sqrt{5}-1)a/2$ and $H=(3\pm\sqrt{5})a/2$. If we set $k=(\pm\sqrt{5}-1)a/2$, we get $A=ka, H=k^2a, b=k^3a$; so that the geometric progression is a, A, H, b.

Other solutions were offered by: M. Dreiling, Collegeville, Ind.; A. MacNeish, Chicago; C. W. Trigg, Los Angeles, Max Beberman, Shanks Village, N. Y.; Hugo Brandt, Chicago; Aaron Buchman, Buffalo, N. Y.; V. C. Bailey, Evansville, Ind.; and the proposer.

2180. *Proposed by Hugo Brandt, University of Md.*

Find the sum, δ_n, of the first n terms of the sequence: 0, 7(1), 26(3), 63(9), 124(2.7), . . .

Solution by Max Beberman, Shanks Village, N. Y.

$$S_n=\frac{1}{9}\sum_1^n 3^x(x^3-1).$$

(Reference: Boole, *A Treatise on the Calculus of Finite Differences*, New York, Sheckert and Co., 1931, Chapter IV, p. 62 ff.)

In general,

$$\sum_1^n a^x\phi(x)=a^n\phi(n)+\frac{a^n}{a-1}\left\{\phi(n)-\frac{a}{a-1}\Delta\phi(n)+\frac{a^2}{(a-1)^2}\Delta^2\phi(n)-\cdots\right\}+C$$

where C is an arbitrary constant and $\phi(x)$ is an integral, rational function of x. As usual

$$\Delta\phi(x)=\phi(x+1)-\phi(x)$$

and

$$\Delta^2\phi(x)=\Delta(\Delta\phi(x)).$$

Now, in our case, $a^x=3^x$ and $\phi(x)=x^3-1$

Thus

$$\begin{aligned}\Delta\phi(x)&=[(x+1)^3-1]-[x^3-1]=3x^2+3x+1\\ \Delta^2\phi(x)&=[3(x+1)^2+3(x+1)+1]-[3x^2+3x+1]\\ &=6x+6\\ \Delta^3\phi(x)&=6\end{aligned}$$

and

$$\Delta^k\phi(x)=0 \quad \text{for} \quad k\geqq 4$$

Hence

$$9S_n=\sum_1^n 3^x(x^3-1)$$

$$=3^n(n^3-1)+\frac{3^n}{2}\left\{n^3-1-\frac{3}{2}(3n^2+3n+1)+\frac{9}{4}(6n+6)-\frac{27}{8}\cdot 6\right\}+C$$

or

$$S_n=\frac{3^{n-1}}{8}[4n^3-6n^2+12n-15]+C.$$

To find C, we make use of the fact $\delta_1=0$.

$$0=\tfrac{1}{8}[4-6+12-15]+C$$

or

$$C=\tfrac{5}{8}.$$

Thus

$$S_n=\frac{3^{n-1}(4n^3-6n^2+12n-15)+5}{8}.$$

Other solutions were offered by: E. C. Rodway, Ontario, Canada; W. R. Talbot, Jefferson City, Mo.; V. C. Bailey, Evansville, Ind.; and the proposer.

2181. *We expect to offer a solution to this in the next issue—Editor.*

2182. *Proposed by Doris Crane, Chatfield, Minn.*

Eliminate A between the equations

$$\begin{cases} x=3\sin A-\sin 3A, \\ y=\cos 3A+3\cos A. \end{cases}$$

Solution by Mildred Hopkins, Kankakee, Ill.

Since $\sin 3A=3\sin A-4\sin^3 A$ and $\cos 3A=4\cos^3 A-3\cos A$, then

$$\begin{cases} x=4\cos^3 A, \\ y=4\sin^3 A. \end{cases}$$

By taking the cube root of both sides of each expression and then squaring and adding the results, we get

$$x^{2/3}+y^{2/3}=4^{2/3}.$$

This is the equation of an astroid, a hypocycloid of four cusps.

Other solutions were offered by: Aaron Buchman, Buffalo, N. Y.; Marie Moore, St. Louis, Mo.; A. MacNeish, Chicago; Max Beberman, Shanks Village, N. Y.; J. A. S. Neilson, Santa Barbara, Calif.; W. R. Talbot, Jefferson City, Mo.; Hugo Brandt, Chicago; E. C. Rodway, Ontario, Canada; V. C. Bailey, Evansville, Ind.; Norman Anning, C. W. Trigg, Los Angeles; Bernard Katz, Brooklyn; G. L. Tuttle, Mt. Pleasant, Iowa.

2183. *Proposed by Clara Lane, Chevy Chase, Md.*

If $x/y=\cos A/\cos B$, prove

$$x\tan A+y\tan B=(x+y)\tan\frac{A+B}{2}.$$

Solution by Max Beberman, Shanks Village, N. Y.

From the given equation we have:

$$x+y=\frac{y(\cos A+\cos B)}{\cos B}. \tag{1}$$

Now

$$\tan\frac{A+B}{2}=\frac{\sin\frac{A+B}{2}}{\cos\frac{A+B}{2}}=\frac{2\sin\frac{A+B}{2}\cos\frac{A-B}{2}}{2\cos\frac{A+B}{2}\cos\frac{A-B}{2}}=\frac{\sin A+\sin B}{\cos A+\cos B}.$$

Thus

$$(x+y)\tan\frac{A+B}{2}=\frac{y(\sin A+\sin B)}{\cos B}. \tag{2}$$

The given equation may be transformed into:

$$\frac{x}{y}=\frac{\sin A\tan B}{\sin B\tan A} \tag{3}$$

or

$$\frac{x\tan A}{y\tan B}=\frac{\sin A}{\sin B} \tag{4}$$

or

$$x\tan A+y\tan B=y\tan B\,\frac{(\sin A+\sin B)}{\sin B}=y\,\frac{(\sin A+\sin B)}{\cos B} \tag{5}$$

$\therefore$ from (2) and (5) ux have: $x\tan A+y\tan B=(x+y)\tan A+B/2$.

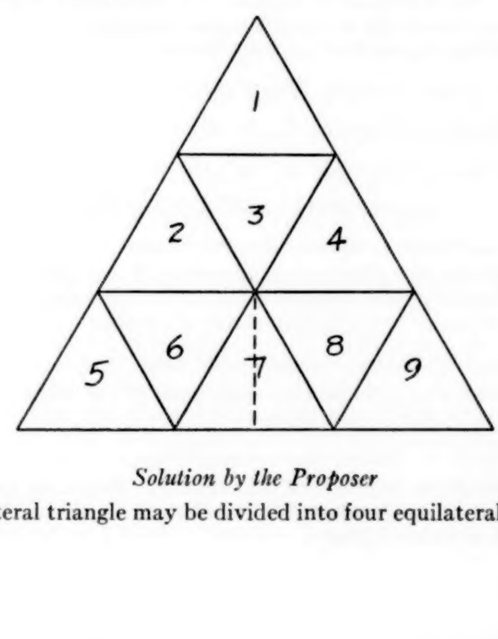
Other solutions were offered by: W. R. Talbot, Jefferson City, Mo.; Leo A. Michuda, Chicago, Ill.

2184. *Proposed by C. W. Trigg, Los Angeles*

1. What is the smallest number of creases necessary in order that an equilateral triangle may be folded, without cutting, into a regular tetrahedron with no open edges? (An open edge is one through which there is straight line access to the centroid of the solid.) How may the folding be accomplished?

2. Show that no more creases are necessary to fold the triangle into a semi-regular hexahedron with two open edges.

3. Show that no more creases are necessary to fold the triangle into a regular octahedron with one open face.



Solution by the Proposer

1. An equilateral triangle may be divided into four equilateral triangles by the

joins of the mid-points of the sides. By folding up along these joins a regular tetrahedron with three open edges is obtained. To close these edges three more triangles are needed. Hence we divide the triangle *ABC* into 9 equilateral triangles by lines parallel to the sides and through the points of trisection of the sides. We number the triangles from 1 to 9 beginning at one vertex and consecutively by rows from the left. We indicate a side common to two triangles by the numbers of those triangles, e.g., 13 is the side common to triangles 1 and 3.

In this configuration, triangles 2, 3, 4, 8, 7 and 6 have a common vertex at the centroid of *ABC*. Now the sum of the angles at the vertex of a regular tetrahedron is 180°. Since folding along the parallels can remove only multiples of 120° from around the centroid, another crease is necessary. Hence we crease the parallels and the perpendicular bisector of 7 from the centroid, a total of seven creases.

The folding may proceed as follows: Bring the two halves of 7 into coincidence by folding up along the bisector and down along 67 and 78. Fold 7 against 6. Bring 3 and 4 into coincidence by folding down along 34, then 3 and 2 into coincidence by folding up along 23. Now fold up along 13 and down along 56 and 89, thus completing the tetrahedron with closed edges. The faces of the tetrahedron are 4, 6, 8 and 9. Permanence may be given the tetrahedron by attaching 9 to 5 with glue or Scotch tape.

2. To form the semi-regular hexahedron, fold down along 26 and 48, then up along 67. Open out the figure by separating 4 and 8. Fold up along 56 and bring 1 into coincidence with 5 by folding down along 13. The hexahedron now has one open face which is closed with 9 by folding down along 89. The open edges are 94 and 19.

3. To form the octahedron, fold up along 78 and down along 48 to bring 4 and 7 into coincidence with 8. Fold up along 89, and down along 13 and 56, thus bringing the free vertices of 1, 5 and 9 into coincidence. The open face is bordered by 1, 2 and 5.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2176, 2177, 2178. *David Freeman, Mill Valley, Calif.*

2170. *Barbara Rosenberg, Brooklyn, N. Y.*

2182. *William Mulac, Chicago, Ill.*

PROBLEMS FOR SOLUTION

2197. *Proposed by Francis L. Miksa, Aurora, Illinois.*

Given three spheres on a plan surface of radii 4, 5, 6 respectively, and tangent to each other. A fourth sphere of radius 3 lies on top and touching the other three. Find the height of center of 4th sphere above the plane.

2198. *Proposed by V. C. Bailey, Evansville, Indiana.*

Regular inscribed and circumscribed polygons of the same number of sides have areas in ratio, 3:4. Find the number of sides.

2199. *Proposed by V. C. Bailey, Evansville, Indiana.*

If the nine-point circle of triangle ABC cuts AB in D and M, making $(AMDB) = -1$, construct the triangle when AB and angle C are given. M is midpoint of AB and D is foot of altitude from C.

2200. *Proposed by Norman Auning, University of Michigan*

Solve the system of equations:

$$(q-2p)^2=(2q-p-3)^2=(p+2q-15)^2=(2p+q-24)^2.$$

2201. *Proposed by C. W. Trigg, Los Angeles*

Only in an isosceles triangle can the line joining a vertex to the internal point of contact of an excircle with the opposite side be a symmedian.

2202. *Proposed by Alan Wayne, Flushing, N. Y.*

In the following addition each letter represents a digit, with different letters representing difference digits. Restore the digits.

$$\begin{array}{r} H\ E\ L\ P \\ T\ H\ E \\ \hline Y\ O\ U\ N\ G \end{array}$$

BOOKS AND PAMPHLETS RECEIVED

MAKING MATHEMATICS WORK, by Gilbert D. Nelson, *Chairman of the Mathematics Department at Lincoln High School, Cleveland, Ohio,* and Herschel E. Grime, *Directing Supervisor of Mathematics for the Cleveland Public Schools, Cleveland, Ohio.* Cloth. Pages ix+630. 15×22 cm. 1950. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $2.40.

ANALYSIS AND DESIGN OF EXPERIMENTS, by H. B. Mann, *Professor of Mathematics, The Ohio State University.* Cloth. Pages x+198. 12.5×19 cm. 1949. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $2.95.

PLANE GEOMETRY, by Walter W. Hart, *Author of Textbooks in Mathematics, Formerly Associate Professor Mathematics, University of Wisconsin.* Cloth. Pages ix+382. 13.5×20.5 cm. 1950. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.00.

AUTHOR'S GUIDE FOR PREPARING MANUSCRIPT AND HANDLING PROOF, by John Wiley and Sons. Cloth. Pages xi+80. 14.5×23 cm. 1950. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $2.00.

GEOMETRY FOR ADVANCED PUPILS, by E. A. Maxwell, *Fellow of Queens' College, Cambridge.* Cloth, 176 pages. 13.5×21.5 cm. 1949. Oxford University Press, 114 Fifth Avenue, New York 11, N. Y. Price $2.25.

OUTLINE OF A METAPHYSICS, by Franklin J. Matchette. Cloth. Pages xiv+108. 13.5×21.5 cm. 1949. The Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $3.75.

PHENOMENA, ATOMS AND MOLECULES, by Irving Langmuir, *General Electric Company, Schenectady, New York.* Cloth. Pages xi+436. 15×23 cm. 1950. The Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $10.00.

GEOMETRICAL CONSTRUCTIONS WITH A RULER, Translated from the First German Edition (1833) by Marion Elizabeth Stark, *Professor of Mathematics, Wellesley College.* Cloth. 88 pages. 16.5×24.5 cm. 1950. Scripta Mathematica, Yeshiva University, New York, N. Y. Price $2.00.

THE NATURE OF NATURAL HISTORY, by Marston Bates, *Rockefeller Foundation Headquarters, New York, N. Y.* Cloth. 309 pages. 15×23.5 cm. 1950. Charles Scribner's Sons, 597 Fifth Avenue, New York 17, N. Y. Price $3.50.

LET'S LOOK UNDER THE CITY, by Herman and Nina Schneider. Paper. 38 pages. 20×25.5 cm. 1950. William R. Scott, Inc., 513 Avenue of the Americas, New York 11, N. Y. Price $1.50.

DISCOVERY PROBLEMS IN GENERAL SCIENCE, A WORKBOOK FOR NINTH GRADE SCIENCE, by Theodore E. Eckert, M.S., *Assistant in Science Education, Department of Rural Education, Cornell University.* Paper. Pages iv+284. 19×26 cm.

1950. College Entrance Book Company, 104 Fifth Avenue, New York 11, N. Y. Price 90 cents net to schools plus transportation charges.

HIGH SCHOOL STAFF AND SIZE OF SCHOOL, by Ellsworth Tompkins, *Specialist for Large High Schools*, and Walter H. Gaumnitz, *Specialist for Small and Rural High Schools.* Circular No. 317. Paper. Pages v+24. 20×26 cm. 1950. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price 20 cents.

STATE CERTIFICATION REQUIREMENTS FOR SECONDARY SCHOOL TEACHERS OF HEALTH EDUCATION AND PHYSICAL EDUCATION AND FOR ATHLETIC COACHES, by Frank S. Stafford, *Specialist for Health Education, Physical Education, and Athletics.* Bulletin 1949, No. 16. Pages iii+33. 14.5×23 cm. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.

BOOK REVIEWS

GIANT BRAINS or Machines That Think, by Edmund Callis Berkeley, *Consultant in Modern Technology.* Cloth. Pages xvi+270. 14×21 cm. 1949. John Wiley and Sons, Inc. 440 Fourth Avenue, New York 16, N. Y. Price $4.00.

Look at the two words in the title above and try to guess the nature of the book. The second title in smaller type gives the basis for a better guess. The machines discussed here are the great mechanical computers, all built in the past ten years, and now in constant use at M.I.T., at Harvard, at the Moore School of Electrical Engineering at the University of Pennsylvania, and the machines of Bell Telephone Laboratories. In addition to these Chapter 9 describes the operation of the Kalin-Burkhart Logical-Truth Calculator; Chapter 10 discusses new devices and their application to new machines planned or in process of construction. The book is so written that one may read just a little about each machine and get the general idea of what it will do, or he may use his physics and mathematics to study how and why the machines operate. Nearly fifty pages are used for three supplements which discuss the words and ideas used, the mathematics employed, and an excellent set of references for additional study by those interested. The book starts with a short chapter on the thinking process and the types of thinking that can be done mechanically. This is followed by a discussion of the systems for handling information, a description and explanation of the devices used in the original Simple Simon machine, and a chapter on the punch-card calculating machines, with the various types of operations that can be successfully handled. The next four chapters give descriptions and explanations of the four great types of machines mentioned above, with diagrams and the mathematical equations to show how the operations are handled and the results obtained. The last two chapters are material for everyone to read and to consider fully. They are entitled "The Future" and "Social Control"; everyone needs to give the ideas discussed here personal attention because he will be affected by them.

G. W. W.

MEASURING OUR UNIVERSE, by Oliver Justin Lee, *Professor of Astronomy and Director, Emeritus, Dearborn Observatory, Northwestern University.* Cloth. Pages x+170. 14×21.5 cm. 1950. The Ronald Press Company, 15 E. 26th Street, New York 10, N. Y. Price $3.00

This is a volume of the *Humanizing Science Series*, written for the general reader who is interested in learning how the astronomer can measure the almost infinite distances of cosmic space, the diameters of stars that seem to be but points of light, and the directions and speeds they are traveling. Since the author is writing for the general public he must explain the units of measure and the precision methods. A short chapter is used to develop these units, guiding the reader from the *cubit*, the *hand* and the *digit* to the *astronomical unit*, the *light*

year, and the *parsec* and *megaparsec*. For the scientist the language is a bit awkward, for inches, feet, millimeters, meters, ounces, tons milligrams, and kilos seem to be thoroughly mixed. But from this jumble of units, set in not for the scientist but for the lay reader, he goes on to the wonderfully precise measuring machines used by the astrophysicist and the astronomer.

The introduction of the metric system of measurement; the supreme accuracy of the great Michelson in measuring the standard meter in wavelengths of the red line of cadmium light; his application of his instrument of high precision the interferometer, in the measurement of the diameter of the great star Betelgeuse; and progress by many others continues the story of accurate measurement and powerful machines. In the few pages on "Our Little Solar System" he opens the way to greater distances across the expanse of the Milky Way, then on to distant nebulae. A few pages on the giant reflector of Palomar completes the book. This book should be on your own shelf and in the school library.

G. W. W.

PLANE AND SPHERICAL TRIGONOMETRY, by M. Richardson, Ph.D., *Assistant. Professor of Mathematics, Brooklyn College*. Cloth. Pages xiv+343+xxiii+138. 15×21.5 cm. 1950. The Macmillan Company, New York, Price $3.75.

The author in the preface points out that justification is required for the publication of another textbook in trigonometry, and states that this text is an attempt to combine instruction in mathematical reasoning with useful and elementary applications. In general this text seems distinctly superior to many now on the market. It contains much more material than is the case with many books planned for a brief course, although some of this, as indicated in the text, could be omitted without destroying the continuity of the course. (Examples of topics not usually found in texts are a review chapter on algebra and geometry; and extensive discussion on the calculation of π; discussion of the calculation of trigonometric tables using infinite series.)

The acute angle is discussed first, followed by the general angle, but the material is so written that this order could be reversed with no serious inconvenience. There is an ample supply of exercises, with answers to the odd numbered problems. Checking the answers to a random sample of applied problems showed careful consideration of the question of accuracy which can be obtained with data of a certain degree of accuracy, as opposed to the vicious practice often found which gives a careful discussion of the question and then utterly disregards this discussion in giving answers to exercises.

The reviewer was impressed by the care with which definitions were given and with which statements were so made that later work in mathematics would not contradict what was learned from this text. The explanations are often longer than customary, and should prove very helpful to the student. Any objections are relatively minor—the definitions of the principal values of the inverse functions are justified because of their convenience in the calculus, the student is not informed that alternative definitions may be encountered; some instructors would prefer that tables of values of the secant and cosecant were available; the footnote on page 212 relative to Shanks' calculation of π might have been given added interest by pointing out that modern electronic calculators have found an error in his value.

Tables are bound with the book including the usual four and five place tables. In some parts, these tables seem a little crowded in appearance. In general, however, this text would seem to be one of the superior texts on the market. It should certainly be considered for adoption unless the situation definitely requires a very brief treatment of trigonometry.

CECIL B. READ
University of Wichita

ANALYTIC GEOMETRY, by Lyman M. Kells, *Professor of Mathematics, United States Naval Academy*, and Herman C. Stotz, *Associate Professor of Mathe-*

matics, United States Naval Academy. Cloth. Pages viii+280. 15.5×23.5 cm. 1949. Prentice-Hall. Inc., New York, N. Y. Price $2.85.

This is a standard text for a beginning course. The treatment would probably be classified as a departure from the traditional, but not a radical departure. For example, vectors are introduced early in the book, but the development of the subject matter does not involve extensive use of vector concepts, such as vector products. It seems surprising to discover the topic of translation of axes introduced on page 24, yet it is of value here and at other places where it appears at irregular intervals. Likewise it is not traditional to insert chapters on polar coordinates and parametric equations between the circle and the conic sections, but the order may have distinct merit.

There is ample supply of exercises with answers to essentially all of the problems; problems likely to be difficult or involve lengthy computation are so designated. In the development of the point of division formula, the ratio r is taken to be the ratio $P_1P:P_1P_2$, wh:ch is not in accord with the most common practice, but here it is largely a matter of convention. In the treatment of the normal form of the equation of a line, the convention used is that p is positive, and that omega is a positive angle. In these situations, and others, as for example the orientation of axes in space, the student is not told that he may encounter other conventions—the implication would be from the text discussion that these are mathematical truths, allowing no variation.

In many respects the text offers interesting possibilities, certainly it merits consideration when a change of text is desired. An unusual table gives, for n from 0 to 100, $\sqrt{n}$, $\log_{10} n$, $\log_e n$, $\sin n°$, $\cos n°$ $\tan n°$, and $n°$ to radians.

CECIL B. READ

INTRODUCTION TO THE THEORY OF PROBABILITY AND STATISTICS, by Niels Arley, *Assistant Professor of Physics, Institute for Theoretical Physics, University of Copenhagen,* and K. Rander Buch, *Assistant Professor of Mathematics, Institute for Applied Mathematics, Denmark Institute of Technology.* Cloth. Pages xi+236. 15.5×23.5 cm. John Wiley and Sons, Inc., 440-4th Ave., New York 16, N. Y. 1950. Price $4.00.

The title of a book does not always indicate the degree of maturity expected of the student. If a teacher who has had no background beyond a first course in educational statistics and the brief treatment of probability given in college algebra tries to read this book, it will no doubt be an unsatisfactory experience. In spite of the statement on the book jacket—"An elementary study of the subject with special emphasis on its practical applications"—the reader will need a good command of the calculus. Mention is made of the Stieltjes' integral, vector analysis, matrix theory, to mention just a few topics.

For the reader who wishes to follow recent literature, however, this book provides a very fine introduction. In its original Danish, the book has been of little use to English speaking mathematicians. The first chapter, relatively elementary in nature, introduces the reader to various definitions of the concept of mathematical probability. The next two chapters, likewise rather elementary, and requiring no extensive mathematical background, present elementary theorems. The remainder of the book assumes a greater degree of mathematical maturity. The first eight chapters are devoted largely to mathematical theory; the last four to applications, in particular to statistics, the theory of errors, and the theory of adjustment. As a single example of a practical application is the discussion of the problem of rejection of a measurement conspicuous by its considerable deviation from the other measurements (this is also in this text an illustration of an unsatisfactory index—an attempt to again locate this material was delayed because of the omission of the word *rejection* from the index).

There is a small number of exercises throughout the book, and a set of 90 problems arranged according to chapters is found in the back of the book. No answers are provided. There is a bibliography of approximately forty items, roughly half

of which are written in French or German. The book would very likely not be suitable for a textbook except in a somewhat advanced course; on the other hand it should be a part of the reference library in any college or university science, mathematics, or engineering library.

CECIL B. READ

INTRODUCTION TO THE THEORY OF FOURIER'S SERIES AND INTEGRALS, by H. S. Carslaw, Sc.D., LL.D., F.R.S.E., *Professor of Mathematics in the University of Sydney; Fellow of Emanuel College, Cambridge; and Formerly Lecturer in Mathematics in the University of Glasgow.* Third Edition, revised and enlarged. 1930. Cloth. Pages xii+368. 14×21 cm. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $3.95.

This is one of several outstanding works in mathematics and in mathematical physics which have been made available, often at a marked reduction in price, by this firm. This particular work has been called a landmark in the history of mathematical physics.

The person not familiar with the work will find more material than may be indicated by the title. Following nineteen pages of historical introduction to the concept of Fourier's series, some two hundred pages is devoted to material which would be encountered in many American texts in advanced calculus or theory of functions of a real variable. The scope is indicated by such chapter titles as Rational and Irrational Numbers, Infinite Sequences and Series, Functions of a Single Variable, Limits and Continuity, The Definite Integral, Definite Integrals Containing an Arbitrary Parameter. There is an appendix treating Lebesgue's Theory of the Definite Integral.

A considerable amount of mathematical maturity is required to handle the textual material, an absolute minimum would be a thorough course in integral calculus and even with this background some portions of the book will be found difficult. On the other hand, as a reference work the book is a veritable gold mine. No college or university library should fail to have the text available. To illustrate some of the topics which are discussed, one might mention: Dedekind's axiom, the Heine-Borel Theorem, monotonic functions, Abel's test for uniform convergence, Weierstrass's non-differentiable continuous function.

CECIL B. READ

BASIC THEORIES OF PHYSICS: MECHANICS AND ELECTRODYNAMICS, by Peter Gabriel Bergmann, *Associate Professor of Physics, Syracuse University.* Cloth. Pages viii+271. Table of Contents. Index. Prentice-Hall Physics Series, Donald H. Menzel, Editor. Prentice-Hall 1949. Price $3.75.

This is a substantial text in theoretical physics written for a two-semester course. The principle emphasis is on physical theory but the mathematical apparatus is elegantly done. The theoretical foundations of "classical" physics, that is, Newton's Mechanics and Maxwell's Electrodynamics, are traced from their genesis through the special theory of relativity. The author intends a companion volume devoted to statistical mechanics and the foundations of quantum physics.

Although the attention is concentrated on physical ideas and the mathematical techniques play only the role of "tools," a healthy array of variational calculus, vector and tensor analysis, and Fourier analysis appears on nearly every page. The physics, however, is stated first and the mathematical discussions follow by obvious necessity.

The division of the text is: Part I. Classisal Mechanics (roughly 100 pages); Part II. Electrodynamics (about 150 pages). The exposition is beautiful and clear and engaging to read. The presentation, although self-contained for the graduate student who is mature and adequate, requires supplementary reading, since many of the developments are merely sketched. A good theoretical physics teacher (good teachers are so often theoretical!) would enjoy teaching from this

book since he would be free to supply *what he thought was lacking*. It is well known that far too many textbooks are far too clumsy and wordy and bulky and make both the teacher and the student *book-bound*.

The theoretical physics *in this text* stands as a logically connected structure of the human mind, not as a bewildering collection of formulas and techniques. For this skill the author expresses his indebtedness to his teachers, Ph. Frank at Prague and Albert Einstein. The Preface and the Conclusion read very beautifully.

Each chapter ends with a set of problems, small in number, but eminently demanding of the student. They cannot (as a rule) be worked by "stuffin' a formula." I enjoyed reading the book and I would enjoy teaching it.

JULIUS SUMNER MILLER
Dillard University
New Orleans, Louisiana

PHILOSOPHY OF NATURE, by Moritz Schlick, *One-time Professor of Philosophy at the University of Vienna*. Translated by Amethe von Zeppelin. Cloth. Pages xi+127. Table of Contents. Appendix. Notes. Index. Philosophical Library, New York. 1949. Price $3.00.

This collection of essays, assembled and edited by two students of Schlick (Walter Hollitscher and Josef Rauscher) can be read in one sitting. The author's ambition throughout the discourses is to teach a scientific way of philosophizing and to explain the relations between philosophy and the exact sciences. Schlick apparently had a substantial career in science and mathematics at Heidelberg, Lausanne and Berlin. His work in physics under Max Planck was on "Reflection of Light," while in philosophy he worked in ethics, aesthetics, and logic. He had personal friendship with Planck, Einstein, and Hilbert. At Vienna he held the Chair of Professor of Philosophy of Inductive Sciences, a chair held before him by such giants as Ernst Mach and Ludwig Boltzmann. In 1929 Schlick lectured at Stanford University. He was assassinated in the University (Vienna) on June 22, 1936.

Although the separate essays are reasonably brief and invariably complete in themselves they constitute a general thesis circumscribing the one problem: to examine the philosophic implications of, and to interpret the findings of, physics. The two problems, to discover the truth and to elucidate its meaning, appear throughout. "The exactitude of natural science causes it to be the most fundamental basis from which to philosophize. Only in the analysis of exact knowledge is there any hope of achieving true insight. And exact knowledge is knowledge which can be fully and clearly expressed in accordance with the tenets of logic." Obviously, mathematics is the only method of logically exact formulation.

Although largely devoted to physics the editors have incorporated in the text verbatim notes of Schlick's lectures on the relation of physics to biology. The essential difference between the living and the non-living can only be discovered in processes, he suggests, which remınds one of Bridgman's operational point of view. Does life obey physical laws exclusively? This essay is very stimulating. Do processes within the cell or organism take place in accordance with purely physical laws alone?

This small volume is a good investment for teachers and students alike, whatever their field of inquiry.

JULIUS SUMNER MILLER

SELECTED INVERTEBRATE TYPES, edited by F. A. Brown, Jr., *Chairman, Biological Science Department, Northwestern University*. Cloth. Pages xx plus 597. 235 figures. 15×22.5 cm. 1950. John Wiley & Sons, Inc., 440-4th Avenue, New York 16, New York. Price $.600.

Selected Invertebrate Types was written to serve as a laboratory manual for college courses in invertebrate zoology. Prepared by thirteen specialists, most of whom are members of the Department of Invertebrate Zoology at the Marine

Biological Laboratory, Woods Hole, Massachusetts, it is unlike ordinary laboratory manuals in that it can be used as a text as well as a laboratory guide. But it is not a book of laboratory directions. The method of utilizing the material is a decision left entirely to the person teaching the course.

Profusely illustrated with well labelled drawings, the morphology, anatomy, and physiology of more than a hundred commonly studied invertebrates is adequately described. A bibliography given at the end of the book can assist in more research on any species, if that is desired. It is the belief of the authors of this book that their intensive treatment of each species enables the student to cover greater amounts of material in the short time normally permitted for the study of the invertebrates.

Except for generic and specific designations, no nomenclature is given beyond the phylogenetic listing and arrangement in the table of contents. It should be pointed out that this book is not useful for identifying specimens. Only a few species in each group are considered, and there are no keys. Students must be informed with what species they are working. Here and there changes in conventional classification categories are found. Some of these are in the major divisions—the phyla; for example, Cnidaria is used in place of Coelenterata, and the phylum Aschelminthes incorporates what is normally divided into Trochelminthes and Nemathelminthes. There are other variations such as the above, but classification is not the purpose of the manual.

Selected Invertebrate Types is a nicely arranged volume for most college invertebrate zoology courses. It condenses a quantity of information to save both students and teachers research time and is flexible enough to permit usage in a number of ways. It does not constitute a reference to satisfy all needs. As an elaborate laboratory manual, it will make a fine addition to any student or teacher's library and an excellent course can be built around it.

George S. Fichter
Miami University,
Oxford, Ohio

Biology, by Frank M. Wheat, *Chairman, Department of Biology, George Washington High School, New York, N. Y.;* and Elizabeth T. Fitzpatrick, *Principal, Bay Ridge High School,* and formerly *Chairman, Department of Health Education, George Washington High School, New York, N. Y.* Cloth. Pages ix + 571. 14.5×22cm. 1949. American Book Company, New York, N. Y. Price $3.40.

This is a biology text written especially for tenth grade high school students. Both authors have had years of teaching students at that level and also in supervising other teachers. In preparing this book, they carefully weighed the vocabulary to eliminate technical terminology and used the material in a number of classes before publishing it. The book consists of an introductory orientation to the science of biology and its usefulness in our present world. This is followed by nine units, each composed of a number of problems. For example, the first unit, entitled Living Things Are Composed of Cells, is made up of four problems. Problem 1 asks: What structures of cells have been revealed by microscopes? The text material explains some of the history of cell investigations and also the morphology and physiology of a typical cell. All of this is summarized at the end of the chapter. Each problem is concluded with a number of exercises for individual or class performance, a list of interesting things to do, and questions covering the text material. This sort of treatment is followed throughout all units, which contain good clear pictures and simple well labelled diagrams. An appendix gives information on the collecting, preparation, and care of materials used in the laboratory, charts on height and weight, and nutritive values in foods.

George S. Fichter

Geometry—A First Course, by Paul L. Trump, *University of Wisconsin.* Cloth. Pages xvi+496. 21.5×14 cm. 1949. Henry Holt and Company, 257 Fourth Avenue, New York. Price $2.88.

From any viewpoint this text deserves careful consideration by those engaged in the teaching of geometry. The author has dared to be different on so many counts that certain features are bound to arouse enthusiasm while others may prove controversial. In attempting an evaluation it seems appropriate to consider two principal features: 1. method of presentation of individual topics, and 2. organization of content with reference to definitions chosen and assumptions made.

The methods and procedures used to introduce new material are superior throughout this text. In the first five chapters a serious attempt is made to acquaint the student with the nature of the subject and the kind of reasoning it requires. The headings of these chapters are highly indicative of their content. Following chapter one, which affords an optional introduction to the course through a discussion of earth coordinates, the next four chapter headings are: "Critical Thinking—Reasoning"; "Choosing Definitions and Assumptions in Geometry"; "Basic Constructions—Triangle Assumptions—Practice in Reasoning" and "Introduction to Geometric Proof." In these, as in the remaining ten chapters, the chief method used to introduce new ideas is one which the author calls "exploration." This consists of having the student perform certain experiments or review certain facts in such a way that the truth of the new proposition gradually becomes apparent. Usually there are several exploratory exercises which converge on the same theorem. These provide a skillful inductive approach to new material and they appear to be a direct outcome of the author's classroom experience.

After new concepts have been developed in this manner they may be applied to a wide variety of well chosen exercises. Some of these exercises test critical thinking as well as content. For example in Exercise 34 the student is asked to "Give the conclusions which must follow if you accept the following statements" and later "Upon what unstated assumptions do these conclusions depend?" Some of the exercises which check content are highly ingenious. In Exercise 33 the student is asked to show by means of an appropriate drawing that certain statements are *false*, thereby stressing the fact that a single exception will nullify a generalization and at the same time eliminating certain familiar misconceptions. These are typical of the instructive exercises which are plentiful throughout this text. Those exercises which deal primarily with content tend to emphasize applications wherever possible. Among these are found a great deal of material on vectors and air navigation together with the requisite trigonometry. All numerical operations are consistently performed in accordance with the laws governing approximate computation as set forth in Appendix I.

The matter of review is also abundantly provided for. At the end of each chapter there are two lists of exercises labeled "Check your Progress" and "Review your Progress." One of these is usually a multiple-choice, true-false, or completion test. In addition there are sections called "Check Your Foundations" which review topics from algebra or arithmetic which are to be utilized in the next chapter.

A survey of the content and organization reveals a deliberate effort to choose definitions in such a way that subsequent proofs would be as simple as possible. For example a tangent to a circle is *defined* as a line perpendicular to a radius at its outer extremity. Again, similar triangles are *defined* as triangles having two pair of equal angles. This choice of definitions usually has the desired effect but in some cases it results in a lack of coordination between definitions and related assumptions. The situation in parallel lines will serve to illustrate this point. On page 15 this statement appears "If two straight lines lie in the same plane and will never intersect no matter how far you extend them, then we say the lines are parallel." This statement is fortified on page 78 with the formally stated assumption "Two straight lines lying in the same plane will intersect at one point unless they coincide or are parallel. If they are parallel they never intersect." Then on page 87 the following working definition of parallel lines is adopted with no comment on its connection with preceding assumptions.

"Parallel lines are two lines lying in the same plane such that if they are cut by a transversal, a pair of corresponding angles formed are equal." On page 108 another formally stated assumption is introduced in the same manner in connection with constructions "Through a given point not on a given line, one and only one line can be constructed parallel to a given line." On page 137 formal proof is exemplified for the first time with a full page proof of this curiously worded theorem, "If a transversal cuts two parallel lines, then the angles of any pair of corresponding angles formed are equal." This involves proving all four pairs of angles equal and is but a slight extension of the definition on page 87. No attempt is made to reconcile the various definitions and assumptions on parallel lines until page 222 where the usual indirect argument based on the parallel postulate (p. 108) is suggested. The proof for the construction for a line through a given point parallel to a given line is finally considered on page 301. In this situation there is not only a lack of articulation between related assumptions and definitions, there is also an unaccountable postponement of some of their more obvious consequences.

There is another consideration relative to assumptions which must be noted in a text where so much prominence is given to their selection. Some of the 53 assumptions listed are definitely unnecessary. It is unnecessary to state the two formal assumptions on parallel lines noted above since one may be deduced from the other. Having assumed on p. 72 that the whole of a thing is equal to the sum of its parts it is unnecessary to particularize this later on p. 388 with the statement that the area of any figure is equal to the sum of the areas of its parts. There is no need for two assumptions on substitution, one for equations, p. 72, and another for inequalities, p. 229. Granting the desirability of postulating the three basic congruence theorems it is not necessary to assume that two right triangles are congruent if hypotenuse and leg of one are equal respectively to hypotenuse and leg of the other. Why assume that vertical angles are equal when this is a logical consequence of other assumptions made at the same time? The inclusion of provable assumptions tends to obscure the distinction between an assumption and a theorem and is, moreover, inappropriate in a subject where the principal purpose is to make the maximum use of deductive argument.

These objections are not minor but they are more than offset by the pedagogical excellence of the text. Perhaps in future editions organization of content will match the general excellence of presentation. This text would then be outstanding in its field.

Frank B. Allen
Lyons Township High School
La Grange, Illinois

An Introduction to Chemical Science, by W. H. Hatcher, *Professor of Chemistry, McGill University*. Cloth. Pages x+449. 14×21 cm. Second Edition. 1949. John Wiley and Sons, Inc., 440 Fourth Avenue, New York. Price $4.00.

This textbook is designed for a terminal course in chemistry for non-science students. It is divided into four parts—inorganic, organic, food, and industrial chemistry—which are intended to give the student basic facts "without the burden of technical knowledge." Laboratory techniques are omitted.

The book brings out clearly and interestingly, particularly in the sections dealing with organic, food, and industrial chemistry, important relationships between chemistry and our daily life. The student will find the reviews of definitions and laws and the summaries at the close of the various chapters of considerable utility.

In the reviewer's opinion the chief fault of the book is the tendency to oversimplify material, particularly in the inorganic section, which does not yield to such treatment. For example, in the chapter dealing with chemical longhand and shorthand the student will obtain the idea that the only way atoms join together in chemical union is by covalent bond formation. There is no indication that the ionic bond is also of importance; the latter concept is introduced at a

much later point when the structure of the atom is discussed. Much would have been gained by an earlier insight into the make-up of the atom.

Although brief mention is made of the transuranium elements, there is nothing on the process of nuclear fission and its impact on our lives.

JACOB KLEINBERG
University of Kansas

ALGEBRA, by A. M. Welchons and W. R. Kreckenberger, *Arsenal Technical High School, Indianapolis, Indiana.* Cloth. Pages xi+580. 21.5×15 cm. 1949. Ginn and Company, Boston, Mass. $2.12.

This freshman algebra text is very carefully written. Special emphasis is placed on the explanation of new words. These are also listed at the end of each chapter along with the page on which the definition may be found. Correct scientific names are used along with common vernacular. It seems that this plan should be very beneficial to the student who continues work in mathematics.

Algebra as an extension of arithmetic is emphasized throughout. The square root of a binomial is developed along with the arithmetical square root problem. The authors develop the most general rules rather than many rules for special cases. Individual differences are taken care of through A, B and C levels of difficulty in the exercises. Only a few chapters, however, have C level work. All chapters contain A level tests and most of them B level tests. There are cumulative tests covering all the material up to that page.

The word problems use many items from the student's school life such as science formula, social science data, athletic data, and student puzzle problems. A good discussion is given on problem analysis and the factors to consider in problem solution. Many literal problems are included. Remedial work is provided in the text at the most logical places.

The chapter on graphs includes both statistical and algebraic material. The discussion on interpretation is good. Pictures and figures are used to introduce chapters and at appropriate places in the content. They are well labeled but are not used as extensively as possible. The historical comments are well done and appropriate.

There are a great many complete solutions which the student may be inclined to follow blindly. Transposition is taught after the underlying principle of the equation is developed. There is some mention of approximate computation but none on significant figures or proper degrees of precision. Signed numbers are approached through opposites, and the dual use of + and − is pointed out. The text is well indexed, has a table of squares from 1 to 100, and has a table of natural trigonometric functions to the nearest degree. The final chapter is "Review by Topics" and contains some very good problems. This book will appeal to many high school students because it is directed toward the things they meet in everyday life.

PHILIP PEAK
Indiana University

THE GENERAL SCIENCE SECTION OF THE CASMT

Donald A. Boyer, chairman, called the annual meeting of the General Science Section to order at 2:40 P.M. on Friday, November 25, 1949. He then introduced Mr. J. Lyell Clarke, Chief Sanitary Engineer, Des Plaines Valley Mosquito Abatement District. Mr. Clarke spoke on "Science and Sanitary Engineering in Action: The Control of Mosquitos and Flies in the Environs of Chicago." Opening remarks were devoted to a discussion of the importance of the mosquito in modern life since the development of the Panama Canal. A period of about fifteen years elapsed between discoveries related to the mosquito and disease and the beginning of public interest in the control of the pest. With the aid of color slides, Mr. Clarke went on to explain the work of mosquito and fly control in and near Chicago. Slides and discussion not only showed the activities of sanitary engi-

neers but also showed a number of species of common and uncommon mosquitos and flies. The control techniques such as swamp drainage, garbage and trash removal, spraying and the application of oil to standing water were explained and pictured for the audience.

Mr. Mahlon Berg of the Kenilworth Public Schools, Kenilworth, Illinois, spoke on the topic, "The Extent to Which General Science Can Benefit by a Sound Elementary Science Curriculum." Mr. Berg substituted as speaker in place of Dr. Harold G. Shane, Professor of Education at Northwestern University, who was unable to be present at the meeting. In his opening comments Mr. Berg pointed out that at present our science curriculum from grades one to twelve is segmented in many ways. In reality it should be a continuous, well integrated program. Presently the programs are divided into two distinct groups, elementary and secondary, and little or no coordination exists between them. And the field itself, within these levels, is often broken and divided with no thought of coordination or continuity. Following the preliminary remarks, Mr. Berg made several points: 1. Elementary Science can be made sound by good planning. 2. A new science curriculum should be developed for the elementary level rather than have the program be a product of science handed down from above. 3. The planned curriculum should be suited to the level of the elementary student. 4. The program should start at grade one. A sound elementary science program can lay the groundwork for a sound general science program, and the total program can enrich the life of children at all age levels.

The final business of the meeting was the report of the nominating committee: *Chairman:* Russell Shedd, Redford Union High School, Detroit, Michigan. *Vice-Chairman:* Fred W. Fox, McGuffey High School, Miami University, Oxford, Ohio. *Secretary:* Bert E. Grove, Lake Forest Academy, Lake Forest, Illinois. This report was approved.

FRED W. FOX, *Secretary*

THE DENTAL APTITUDE TESTING PROGRAM WILL BECOME NATION-WIDE FOR THE 1951 ENTRANTS

SHAILER PETERSON, PH.D.
Secretary, Council on Dental Education of the American Dental Association

The dental school applicant for the class enrolling in the Fall of 1951 will be asked by the dental schools to take a battery of examinations administered by the Council on Dental Education of the American Dental Association. The dental schools have for some time been interested in improved methods of selecting from their applicants those students who have those special abilities and qualities necessary for success in dental schools and for later success in the practice of dentistry. Several dental schools have conducted their own aptitude tests and about six years ago the Council on Dental Education began studying the possibility of developing a battery of tests that might be used by the schools for better evaluating the potential ability of their applicants.

Applicants for admission to dental school for the 1951 Fall classes should make application directly to the dental school or dental schools of their choice. After reviewing their credentials the dental school will decide which applicants should take the aptitude tests in order that test scores be available at the time that the final selection of the class is made.

The School will notify the Council on Dental Education to which persons application blanks for the aptitude testing program should be sent. The application blank will be completed by the applicant and returned to the Council on Dental Education along with (1) three photographs to be used for identification at the testing center, (2) his choice of three testing centers listed in the order of his preference, and (3) a fee of ten dollars which will entitle him to have his records sent to as many as five dental schools, should that many authorize him to take the examinations.

All inquiries about the requirements of the individual schools and about the administration of the Dental Aptitude Testing Program sponsored by the Council on Dental Education of the American Dental Association should be addressed to the individual dental school. The names and addresses of the accredited dental schools may be obtained by writing to the Council on Dental Education of the American Dental Association, 222 East Superior Street, Chicago 11, Illinois.

SUPPLEMENTARY READING IN CHEMISTRY

HERBERT R. SMITH
Milton College, Milton Wis.

American Iron & Steel Institute, 350—5th. Ave., New York
"The Picture Story of Steel"
U. S. Steel Corp. 71 Broadway, New York 6
"Steel Making in America"
Dow Chemical Co., Midland, Mich.
"How Magnesium Pays"
American Steel and Wire Co., 208 S. LaSalle St., Chicago
"The Story of Wire"
Freeport Sulfur Co., 122 E. 42d. St., New York
"Freeport Sulfur"
E. I. DuPont de Nemours & Co., Wilmington 98, Del.
"A Calcavade of Chemistry"
"Chemistry and the Farmer"
"Cellulose, Coal Tar & the Chemist, Salt Extra"
"The Story of Coal, Air, & Water, Nylon Gives You Something"
"Ditching with Dynamite," (Specialized use)
National Cottonseed Products Assoc. Inc., 618 Wilson Bldg., Dallas 1, Tex.
"Cottonseed and Its Products"
"Feeding Practices" (Farm interest)
Proctor & Gamble, Cincinnati, O.
"Soap"
Rohm & Hass Co., Inc., Washington Sq., Philadelphia
"Plexiglas"
Luray Caverns Corp., Luray, Virginia
"The Beautiful Caverns of Luray"
General Motors Corp. Detroit, Mich.
"A Power Primer"
Pillsbury Flour Mills Co., Minneapolis, Minn.
"The Story of Flour"
Corn Industries Research Foundation, 5 E. 45th St., New York 17
"Corn in Industry"
American Forest Products Industries, Inc., 1319—18th St. N.W., Washington 6
"Trees for Tomorrow"
California Fruit Growers Exchange, Los Angeles, Calif.
"The Story of Oranges & Lemons"
The Rubberoid Co., 500 Fifth Ave., New York 18
"Asbestos, The Silk of the Mineral Kingdom"
Asbestos Textile Inst., 12 S. 12th., Philadelphia 7, Pa.
"A Primer on Asbestos Textiles"
The International Nickel Co., Inc., New York 5
"The Romance of Nickel"
Aluminum Company of America, Pittsburg, Pa.
"An Outline of Aluminum"
"Aluminum Paint"

Pepperell Mfg. Co., 160 State St., Boston, Mass.
"Cotton, from Plant to Product"
Monsanto Chemical Co., St. Louis, Mo.
"Phosphorus"
Owens-Illinois Glass Co., Toledo, Ohio
"Glass"
Corning Glass Works, Corning, N. Y.
"Glass and You"
General Electric Co., Schnectady, N. Y.
"The Story of X-ray"
Eastman Kodak Co., Medical Div., Rochester, N. Y.
"X-rays and You"
American Plant Food Council Inc., 910—17th. St. NW, Washington 6, D. C.
"Our Land and Its Care"
International Salt Co., New York, N. Y.
"Salt, The Aristocrat of Minerals"
Standard Oil Co., 50 Rockefeller Plaza, New York, 20 N. Y.
"Conservation"
"Natural Gas"
International Harvester Co., Chicago, Ill.
"Man & The Soil"
"Health from the Ground Up"
"The Story of Bread"
"Make the Soil Productive"
(The first two are splendid but heavy for H.S.)
The B. F. Goodrich Co., Akron, Ohio
"The Wonder Book of Rubber"
Norton Company, Worcester 6, Mass.
"Abrasives, Their History and Development"
The Carborundum Co., Niagara Falls, N. Y.
"The Romance of Carborundum"

1950 SUMMER PROGRAM ON "SCIENCE IN GENERAL EDUCATION" AT HARVARD UNIVERSITY

The Harvard Summer School will offer a program in "Science in General Education" during the 1950 Summer School. This program will be an expansion of the experiment initiated during the summer of 1949.

The program is designed for all those who teach science to non-scientists. It will open on July 10 with an intensive Workshop under the general direction of Professors I. Bernard Cohen and Fletcher Watson of Harvard. This Workshop will last four days and will provide an opportunity for teachers from colleges, junior colleges, and secondary schools (and graduate students who are prospective teachers) to examine the methods, aims, and practices applied in the introductory courses in science in the Harvard General Education program.

During the Workshop there will be ample opportunity for consultations between students and panel members about practical problems involved in teaching science courses. There will be afternoon sessions at which prepared papers will be presented. These papers will deal with such problems as "The Historical Approach and the Use of Historical Documents"; "The Value of Considering Science as an Organized Social Activity"; "The Role of Science in Technology and as a Factor in Social Change"; "The Need for a Viewpoint on the Philosophy of Science"; "Special Problems in the Biological Sciences"; "Aims and Objectives, and Methods of Testing Them." Among the experts who will present the papers will be Professors Philippe Le Corbeiller, Edwin C. Kemble, and Edward S. Castle.

Those able to give more intensive consideration to the General Education

approach to the teaching of science will be able to enroll in a special course, also under the direction of Professors Cohen and Watson, which will begin July 5, include the Workshop, and continue until August 12. It will provide substantive data for use in the teaching of science and will consist of an introduction to the use of historical case materials in the study of science, a general survey of teaching methods in the sciences, an evaluation and testing of objectives, and the methods of organizing and conducting science courses.

In addition to this special course, those enrolled in the program will have the opportunity to choose from three of the General Education science courses: "The Development of Physical Theory from Copernicus to Einstein" (offered by Assistant Professor Gerald J. Holton); "The Philosophy of Modern Science" (by Professor Philipp Frank); and "Human Behavior" (by Professor B. F. Skinner).

Inquiries about the Harvard program on "Science in General Education" should be directed to Harvard Summer School, 2 Weld Hall, Cambridge 38, Massachusetts.

THE QUIZ SECTION

JULIUS SUMNER MILLER
Dillard University, New Orleans, La.

1. A simple pendulum hangs in an elevator. How will its period be effected by (a) an *upward* acceleration of the elevator? (b) a *downward* acceleration of the elevator?
2. A simple pendulum hangs in a railway car. How will its period be effected by (a) the uniform motion of the train in a straight line? (b) the accelerated motion in a straight line? (c) the uniform motion of the train *on a curve?* (d) the accelerated motion of the train on a curve?
3. What is the maximum length of wire which may safely support itself if hung from one end?
4. How do ocean currents from polar regions affect the length of the day?

BRITISH AERIAL PHOTOGRAPHS ON EXHIBITION

The use of photography to detect ancient ruins that are now entirely below ground is a subject of current interest at George Eastman House.

An exhibition is now open there featuring unusual British aerial photographs of archeological sites in Britain. They date back to the Roman conquest.

The showing is first in a series of special exhibitions designed to show varied uses of photography. George Eastman House, the photographic institute at Rochester, N. Y., was opened to the public on November 9, 1949.

Chemical discolorations of the soil and "crop markings" in even a level grain field show the presence of sub-surface archeological sites only through aerial photography. It is this factor which made systematic aerial photography an important archeological tool.

A second group of photographs included in the exhibition features low-altitude aerial photographs showing ruins of famous British castles and religious houses constructed during the Middle Ages.

The entire exhibition is the work of Dr. J. K. St. Joseph of Selwyn College, Cambridge. It was originally shown at the Kodak gallery in London, and later at the art galleries in Leeds and Glasgow.

Use of aerial photography as an aid to archeologists was recognized first during World War I when British fliers in Mesopotamia noted how ancient cities and irrigation systems in the Euphrates valley could be seen in great detail from the air, even though they were below ground.